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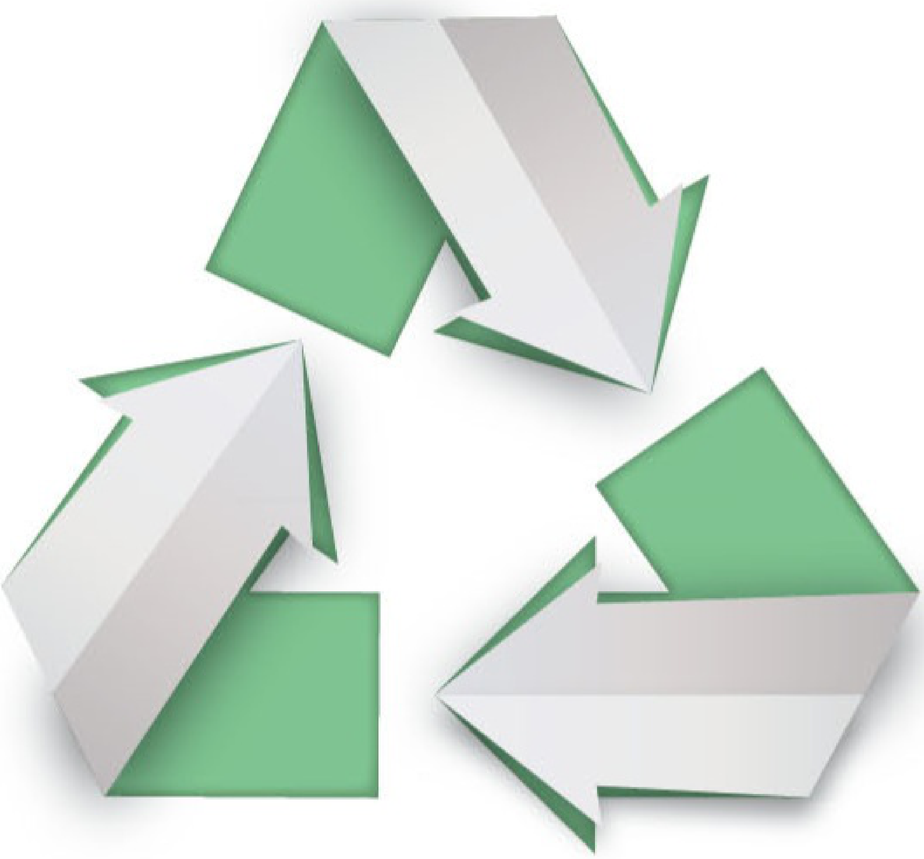

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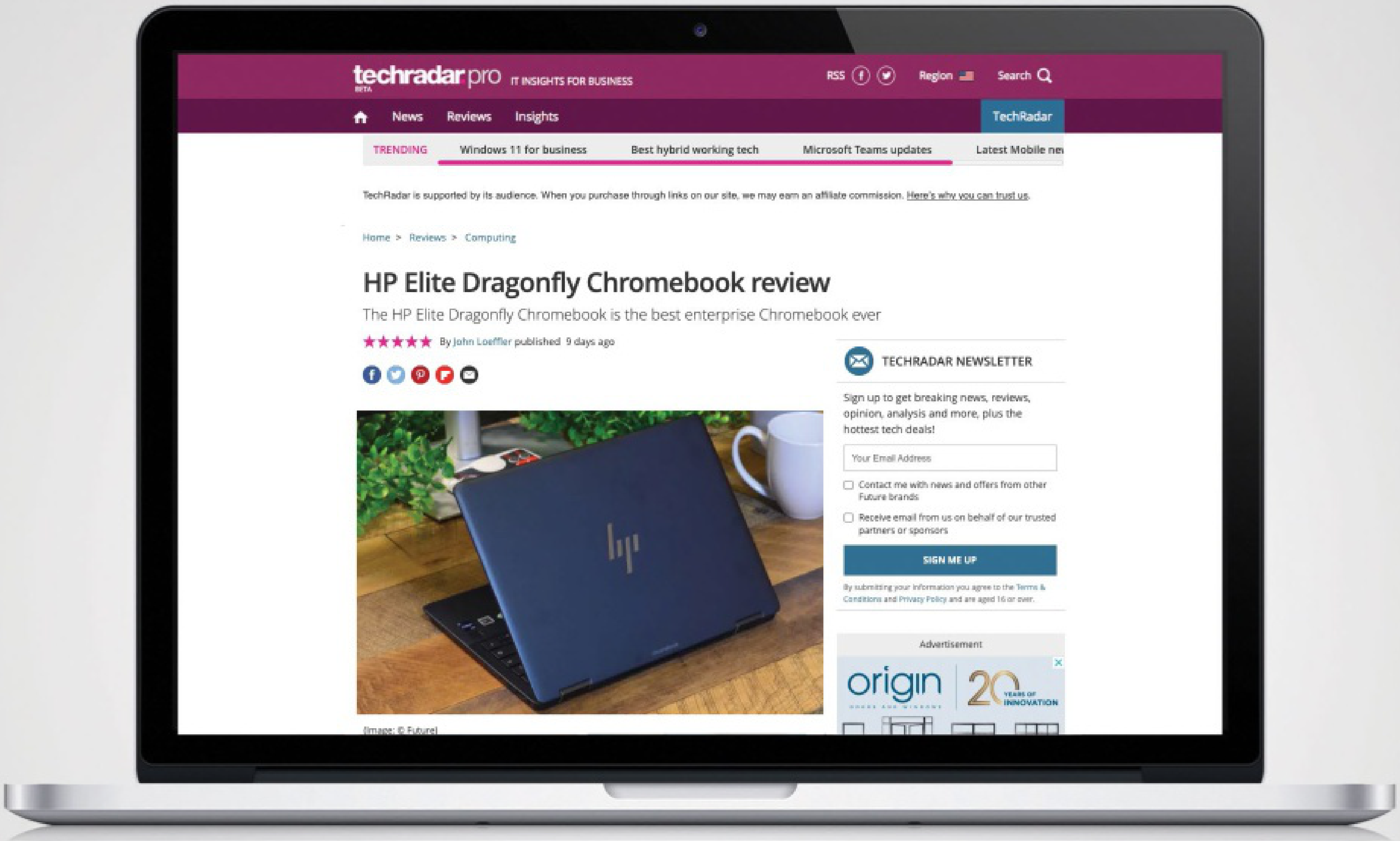

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HP Elite Dragonfly Chromebook review

The HP Elite Dragonfly Chromebook is the best enterprise Chromebook ever

★★★★★ By John Loeffler published 9 days ago

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WHEN IT RAINS...

WHAT A ROLLERCOASTER ride 2022 has been. Obviously, I mean in general, but this being *Maximum PC*, I refer specifically to the last 12 months in tech. The story of the year has to be graphics cards—in January the only way to get a decent GPU was by paying double the RRP for some dodgy-looking deal on eBay. That thankfully came to an end a few months ago as supply normalized and Crypto miners quickly exited the market thanks to rising energy costs and Ethereum's move to Proof of Stake. Now, those same cards are about to become even cheaper, thanks to the release of Nvidia's newest RTX 4000-series GPUs, which Nvidia claims offer a performance boost of between two and four times over their predecessors!

In our labs, we found that those claims don't quite live up to real-world performance, but the RTX 4090 (reviewed on page 74) is still a hugely impressive specimen. Nvidia has achieved a true generational leap with its flagship Ada Lovelace product. We'll find out soon whether that extends to the 4080 products and their confusing RAM/performance configurations, but performance enthusiasts should be excited. Jarred Walton, our expert on all things graphics, has also been taking a deep dive into Nvidia's new tech and what it means for gaming and PC owners in general. Check it out on page 32.

It's also been an interesting year in CPUs. Intel's Alder Lake chips kicked 2022 off with a bang, bringing CPU dominance back to Team Blue for the first time in years—we were so impressed we called the i5-12600K the "best gaming CPU ever" in January. It didn't take long for AMD to clap back with its new 3D V-Cache-enabled Ryzen 7 5800X3D, quickly regaining the support of gamers.

We're set for another showdown with AMD's Zen 4 and Intel's Raptor Lake line both now out in the wild. We were able to squeeze in a review of the top-end AMD Ryzen 9 7950X this issue, with the mid-range Ryzen 7 7700X set to follow next month. We've also just taken delivery of an Intel Core i9 13900K to measure up against AMD's offerings. It's going to be a busy time for Sam and I in the labs.

Speaking of Sam, he put together our cover build for this issue, an AMD gaming system for under $1,000. Of course, it's easy to get carried away with the latest tech, but if you're looking at a Zen 4 chip, you'll also need a new motherboard and some pricey DDR5 RAM. Now is a great time to bag a bargain on a capable previous-gen system for creative tasks and 1080p gaming. The build takes just two hours, and you can see how AMD's system stacks up against the Intel one we built in the last issue. It starts on page 16.

As it's the holiday season, I also put together a Seasonal Gift Guide (thanks to P.Chapman's letter in our September issue for the suggestion!). And in our How To section, Nick Peers offers advice on taking control of your hardware from within Windows, as well as how to finally wrangle that media collection into shape so you can enjoy it no matter where you are. Finally, we break down the new Apple Watch Ultra, see if the Arc A770 is finally an Intel GPU worth buying, and review the much-anticipated *Return to Monkey Island*.

Enjoy the issue!

Guy Cocker

Guy is Maximum PC's Editor-in-Chief. He built his first gaming PC in 1997 to play Tomb Raider on 3dfx, and has been obsessed with all things PC ever since.

↘ submit your questions to: editor@maximumpc.com

THE NEWS

Nvidia's Hot New Card

Both metaphorically and literally

Nvidia's new baby is a beast of a GPU, with up to 76 billion transistors, up from Ampere's maximum of 28 billion.

NVIDIA'S NEW GPU has landed in the form of three new 4000-series graphics cards, and they are beasts. The $1,599 RTX 4090 24GB is a triple-slot 450W monster with 16,384 CUDA cores—50 percent more than the RTX 3090. Next is the $1,199 RTX 4080 16GB with 9,728 CUDA cores, and finally, the RTX 4080 12GB at $899 with 7,680 cores. All three use different versions of the new Ada Lovelace GPU coupled to GDDR6X memory. These have fourth-generation Tensor cores, third-generation ray tracing cores, shader execution reordering, DLSS 3, and clocks over 2.5GHz. These updated technologies, along with bigger core counts and faster clocks, add up to a big performance increase over the Ampere-powered cards. Every metric has been bumped: doubled or more in many cases. Nvidia's claims include the new cards running games between two and four times as fast as their predecessors. Anything with ray tracing is particularly blessed.

So Nvidia has built a hot graphics card using new GPUs complete with big performance gains. Everybody's happy, right? Not really. The new cards aren't cheap and the price structure deviates from usual practices. Using completely different GPU dies on the two RTX 4080 versions has ruffled feathers. Previously, cards with the name number used the same basic chip, and it has been argued that the smaller RTX 4080 12GB should be called the RTX 4070 and be considerably cheaper. It has 20 percent fewer CUDA cores, and a narrower, slower memory bus, while being $400 more than an RTX 3070. The RTX 4080 16GB is particularly expensive, given the RTX 3080 launched at $699, and the new equivalent is over a grand. Nvidia says the 4080 12GB is faster than a 3090Ti and deserves the 4080 name.

There has been speculation that Nvidia is keeping its 4000-series priced above the 3000-series to sell off the older stock. It's a tough time to sell expensive kit, no matter how good it is. When Nvidia started work on the 4000-series, cryptocurrency mining was huge, and cards flew off the shelves. Nvidia switched to the more expensive TSMC 4nm process, at twice the cost of the previous 8nm process. Now cryptocurrency mining has tanked, leaving unsold 3000-series stock, and in the current economic climate, price is more of a factor.

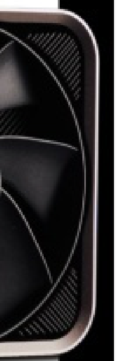
Nvidia has also suffered issues with power. The new cards are hot, with the RTX 4090 having a TDP of 450W, with the two 4080s at 320W and 285W respectively. That's led to potential problems with older PSUs, particularly with the 4090 which can hit 600W. Not all 12VHPWR cables (particularly adapter cables) are up to the task—you need a 1000W+ ATX 3.0 PSU and cables designed for the job.

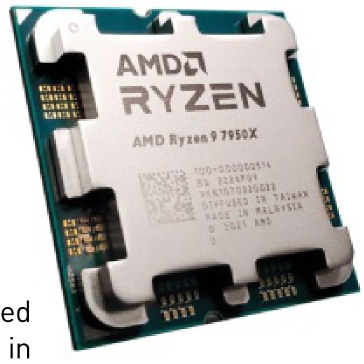
Meanwhile, Nvidia and EVGA have parted ways. EVGA will no longer make Nvidia-powered graphics cards, which is a shock as the company has only ever sold Nvidia cards. According to EVGA's CEO, Andrew Han, the company felt 'restrained' by Nvidia. EVGA will continue to support the Nvidia cards it has sold and has enough stock to honor warranties. What the company does now is a mystery, as it has effectively closed 78 percent of its business and has no plans to manufacture or sell any more graphics cards.

The company reportedly lost money on many of its RTX sales due to over-ordering, which Nvidia allegedly wasn't helpful with. The problem is profit margins. Nvidia can undercut its third-party partners, which can make it tough to squeeze a profit out of selling cards, even with a healthy sales volume. Perhaps AMD and Intel will make offers EVGA will find hard to resist, but for now, EVGA is out of the graphics card business and Nvidia has lost a long-standing and capable partner.

The graphics card market is in a mess, with shortages and changes in the market to be worked through. Things will calm down next year, when we will see mid-range 4000-series cards, and possibly the 4090Ti (using the full 18,000 CUDA cores on the AD104-400 GPU). AMD's RDNA 3 cards will also be along soon. The timing of the 4000-series may be unfortunate, but these are incredibly potent cards. Read our verdict on the RTX 4090 on page 74. **–CL**

> “Nvidia's new cards are hot, with the RTX 4090 having a TDP of 450W.





AMD (BRIEFLY) BACK ON TOP

TOP DOG STATUS MAY BE BRIEF

WHEN AMD'S NEW ZEN 4 PROCESSORS launched, they reached benchmarks that put AMD back on top of the leaderboards in multithreaded performance. The top dog, the Ryzen 9 7950X ($699, see review page 76) broke benchmarking world records. It has a peak clock rate of 5.7GHz on two cores but, with some cooling, can be pushed to 5.8GHz on all cores. AMD's own overclocking team, using a Corsair AIO cooler, managed a 5.4GHz all-core boost, and claimed a world record for a 16-core Cinebench R23 benchmark at 40,498. The chips have drawn attention for their heat too, a properly toasty 95°C. Consuming over 200W doesn't help but neither, apparently, does a thick integrated heat-spreader added to ensure compatibility with older AM4 coolers. Sadly for AMD, a reckoning with Intel's 13th Generation chips means that Zen 4's moment in the sun looks likely to be a brief one. **–CL**

INTEL'S $329 ALCHEMIST

GPUs to shake up the mid-range

WE'VE BEEN WAITING for Intel to ship some useful graphics cards for a while, but now the new Arc Alchemist A750 and A770 (see review, page 78) are here. The 8GB A770 costs $329 and Intel will build a 'limited edition' version with 16GB RAM ($349). The A770 has a 2.1Ghz GPU with 32 Xe-cores. Below this is the A750 ($289), which has 28 Xe-cores running at 2.05GHz. Intel's versions look similar; two slots, two fans, and a TDP of 225W. Performance from all three won't be too different, given the similar specs. Just how good they are will depend on the drivers, and work appears to have been done here. Benchmarks show the newer cards are 20 percent faster than the first samples. The A770 pretty much matches the RTX 3060 and is cheaper too. These cards won't trouble Nvidia's or AMD's finest, but they could shake up the mid-range market. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

✓ **JET PACKS NOW ON SALE**
If you have $400,000 and nerves of steel, Gravity Industries' 75lb jet pack has five gas turbine engines capable of going 80mph.

✓ **ROBOTIC COBBLER**
Nike has invested in a robot named BILL (Bot Initiated Longevity Lab) that can clean and repair sneakers.

✓ **ELECTRIC HELICOPTERS**
United Airlines is to invest in 200 electric 'air taxis', small aircraft for flights of up to 60 miles.

TRAGEDIES

✗ **TESLA RECALL (AGAIN)**
Yet another Tesla recall. This time, the window's obstruction recognition software has a bug.

✗ **AAA GAMES NOW $70**
Ubisoft has fixed its new high-end games at $70. Microsoft still sells at $60, but that's expected to change soon too.

✗ **GOOGLE PAID SEARCHES?**
The DoJ has accused Google of paying phone manufacturers 'billions' every year to ensure it's the default search engine.

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INTEL'S 13TH GENERATION

Raptor Lake looking fierce

AFTER WHAT SEEMED like a quiet summer, we're now experiencing a flood of new silicon, including Intel's 13th-generation processors. The hybrid design mixes performance cores and efficiency cores. We've PCIe 5.0, DDR5, at least five clever boost methods and more. There's no node shrink, instead, it uses the same Intel 7 process. For that innovation, we'll have to wait for Meteor Lake. Intel claims the world's fastest desktop processor title and best gaming experience. There will be 22 versions in all, the initial ones being the Core i9-13900, i7-13700, and i5-13600, available in K, and KF versions (the latter without integrated graphics).

The top-dog i9-13900K ($589) has eight performance and 16 efficiency cores with a maximum clock of 'up to 5.8GHz', while the i5-13600KF (6p+8e) is $294. Raptor Lake chips run more efficiency cores than Alder Lake (there are eight more on the die), which gives a decent bump to multi-threaded performance. They also get hefty frequency increases and larger L2 caches. This equates to an i9-13900 being 15 percent higher at single-thread performance and up to 41 percent higher in multi-thread performance measured against the previous generation's i9-12900, according to the company.

Intel has talked about Raptor Lake chips reaching a peak of 6GHz, and no doubt has something in reserve to match AMD's promised V-Cache version of the Zen 4. Expect AMD and Intel to compete to claim the accolade of the world's best gaming processor, seen as proof of who makes the best chips. Expect our review of the Intel Core i9-13900 in the next issue. **–CL**

Intel's 13th generation is a refinement of Alder Lake, designed to counter AMD's Zen 4.

STADIA'S DEAD

Google pulls out of cloud gaming

GOOGLE'S CLOUD game system Stadia was launched in 2019, promising top-tier 4K games on minimal hardware. The idea was sound but the implementation wasn't as solid as hoped. While Stadia was excellent from a technical perspective, with 4K resolution, surround sound, and smooth gameplay, Google didn't support it with original content and closed the doors of its in-house developers last year, losing a great deal of talent in the process. The writing has been on the wall for Stadia ever since.

The game library remained too small and was mainly made up of older titles, meaning it didn't attract customers across from other platforms. It also didn't have a clear market position and compared unfavorably next to the breadth and quality of the Xbox Game Pass.

Stadia is now closed to new customers and is due to be switched off in January. All customers will receive refunds on software and hardware made through its Stadia or Google stores, which is some compensation to the small and dwindling number of fans who stuck with it.

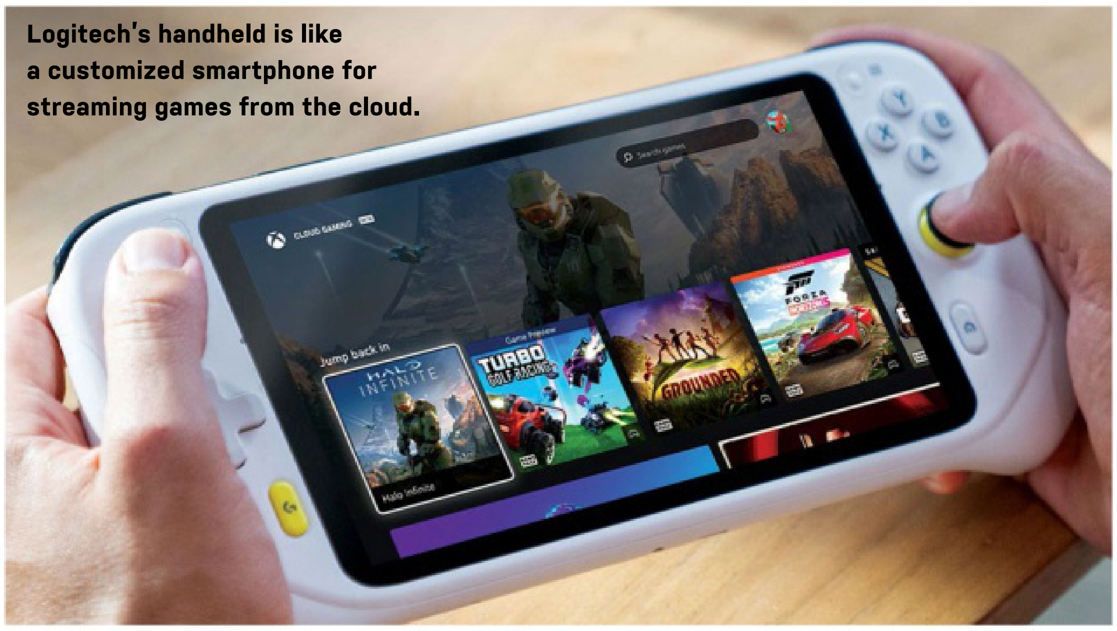
This little experiment undoubtedly cost billions, though Google isn't exactly short of capital. It's also a company that isn't shy about walking away from any project that isn't going well. It has just decided to ditch its Pixelbook laptop, meaning that after a decade of building Chromebooks, it will now leave the market to others.

Stadia and Pixelbook join an extensive list of products and services that Google has killed over the years. However, it also has a habit of returning to projects years later, so Google may well try again in a few years or roll it into another project. The technology is sound, and Google says it will be using it elsewhere and making it available to partners. In the meantime: play 'em while you've got 'em. **–CL**

Logitech Goes Cloud Gaming

THE HANDHELD GAMING MARKET has another contender, Logitech's G Cloud Gaming Handheld. It's a little over 10-inches across and 1.3-inches thick, has a 7-inch 16:9 touchscreen running at 1080p, with a brightness of 450 nits and a refresh rate of 60Hz. On the outside, there are all the gaming buttons you need, while inside there's a SnapDragon 720G processor, an 8-core chip running at up to 2.3Ghz with 64GB of memory. The 6,000mAh battery is good for over 12 hours of gaming, an improvement over rivals such as the Steam Deck, which offers two hours. All this runs on a customized version of Android. First impressions of the G Cloud hardware is that it's large enough for a good gaming experience, while being lightweight at just over 1lb.

G Cloud games come via subscription services such as Microsoft's Game Pass or Nvidia's GeForce Now. You can also use Steam Link, or download remote-play games from Google. The serious gaming power is supplied by the cloud, so you'll need a solid Wi-Fi signal—there's no 5G, so gaming in the wilderness is out. All this will cost $349, and though the Steam Deck is more expensive, it's a gaming rig in a handheld, so you can play games locally, as well as stream games. The G Cloud isn't a direct rival as it's cloud-only. Good luck to Logitech, but this isn't an easy market in which to prosper. Cloud gaming has been hailed as a 'thing' for a while, but success is proving elusive. The price is already drawing criticism, as well as comparisons to its more powerful rivals. Google has tried this market too, and that didn't end well (see left). **–CL**



Logitech's handheld is like a customized smartphone for streaming games from the cloud.

Ethereum goes green

After a few delays, cryptocurrency Ethereum (second largest by value) has switched from proof-of-work to proof-of-stake, ending the need for racks of systems to mine coins. Instead you 'mint' them, with each node rewarded when it validates a transaction. Power consumption has been reduced by 99 percent, but there has been a 'hard fork' on the blockchain, meaning traditional mining can continue. Bitcoin currently burns enough power to run Argentina, but the two systems aren't synonymous. Bitcoin's fans say it provides a genuine decentralized, secure, and democratic currency. However, criticisms—and legal obstacles—are growing. **–CL**

Musk to Buy Twitter

First, he said he would, then he wouldn't. But now Elon Musk is finally set to buy Twitter. The price is yet to be agreed before any more disagreements—$44 billion, or $54.20 per share. Musk has been vocal about his reasons for buying the social media platform, saying he wants to protect free speech.

The deal was announced days before it was due to go to court and follows acrimonious statements over active users on all sides. Musk highlighted the number of dodgy accounts—recent analysis shows that 19.42 percent of all accounts are spurious. We'll wait for the deal to go through before we believe it, however. Musk is an impulsive man. **–CL**

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Jarred Walton

TECH TALK

Ethereum ends mining, EVGA exits GPU market

THE PC LANDSCAPE IS ABOUT TO see the biggest upheaval in years. AMD Zen 4 CPUs, Intel Raptor Lake, Nvidia Ada Lovelace, and AMD RDNA 3 are all here or coming soon. But perhaps just as big and impactful on the PC enthusiast community is the successful transition of Ethereum from proof of work mining to proof of stake minting—the very next day, EVGA announced that it would be closing down its graphics card division.

Let that sink in. EVGA, the biggest vendor of Nvidia graphics cards in the US—accounting for roughly 40 percent of the market—called it quits one day after mining ended. The two might be unrelated. Nvidia's CEO stated that EVGA's founder Andrew Han had been "thinking about moving on for several years". The time has apparently arrived and Han says he has no plans to sell the company or make cards for other companies. On the other, we can't help but think cryptocurrency played a role.

This boom-and-bust cycle was the fourth since Bitcoin's inception and, in many ways, the most impactful on the world markets. Cryptocurrencies reached a peak market cap of nearly $3 trillion in November 2021, but their total worth currently sits at less than $1 trillion. Numerous startups have come and gone, taking investor dollars with them.

Ethereum mining remained profitable, just not as much as at its peak. The best GPUs could still make about $3 per day up until the merge. The network hashrate before then was still plugging along at a heady 900TH/s. To put that in perspective, it would have taken 10 million RTX 3080 cards to power the Ethereum network—and because there were lots of different GPUs participating, it's a reasonable estimate that over 20 million graphics cards were mining Ethereum up to the end.

Now, those cards are in search of some other coin. Except nothing else even comes close. Ethereum constituted up to 97 percent of all GPU mining over the past couple of years. The influx of hashrate to alternative coins has caused profitability to plummet and, with rising electricity costs, most GPUs would spend more on power than they generate in cryptocurrency.

Unless something changes, we expect a flood of used mining GPUs to enter the market. Inventories of new graphics cards have been building up for the past six months, as supply finally outstripped demand. Prices are falling to acceptable levels but are likely to fall even further—that seems to be part of the impetus for EVGA shuttering its graphics division.

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> In the early hours of September 15, 2022, Ethereum successfully transitioned from proof of work to proof of stake. GPU mining profitability plummeted shortly after.

Han cited 'disrespect' from Nvidia, pointing to the RTX 3090 Ti Founders Edition pricing, where Nvidia dropped its card from the initial $1,999 launch MSRP to just $1,099 this summer, without giving its partners a heads-up. Instead of making hundreds of dollars off each card sold, EVGA is losing hundreds. This was just too much.

There's more to the story. Nvidia's RTX 4090 and 4080 cards have increased the generational pricing but, after the 3090 Ti, how can Nvidia's partners be sure prices will stay high? If Nvidia can compete with its AIB partners and drop prices to levels they can't hope to match without losing money, the best decision may be to stop playing the game. RIP, EVGA.

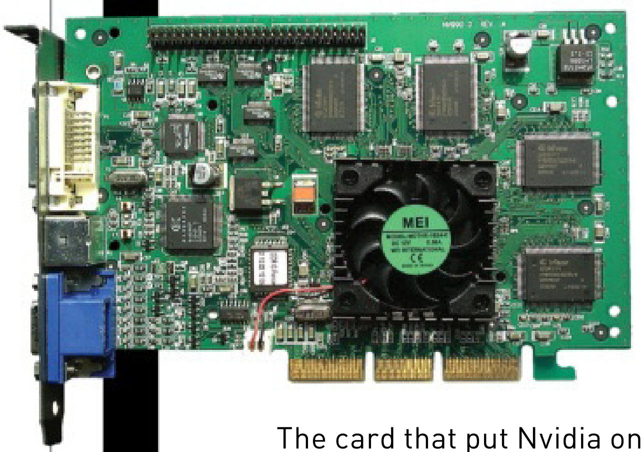
There's a silver lining in that the glut of graphics cards from mining and existing GPU inventories mean we're less likely to see a repeat of 2020's GPU Scalperpalooza. We have a full review of Nvidia's RTX 4090 in this issue plus Intel's Arc A770, both of which are terrific cards. Too bad for Intel that its GPUs are arriving at what might be the worst possible time.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

THE LIST

THE TOP FIVE NVIDIA GPUs

WITH THE LAUNCH of the RTX 4090 (reviewed page 74), Nvidia has maintained its position as the manufacturer of the world's fastest consumer graphics card. But it's been a long road, one that has taken it from starting out in the highly competitive 90s era of 3D specialists to acquiring one-time rival 3dfx, working on the first Xbox, and now supplying the graphics tech for the Nintendo Switch. But the real story has always been its fight with AMD/ATI. Here are the GPUs that fought on the front lines.



5

NVIDIA GEFORCE 256

Release date: 1999

The card that put Nvidia on the map is notable for two things—it took 3D rendering tasks away from the CPU and directly onto the graphics card, causing Nvidia to coin the term 'GPU' or Graphics Processing Unit. The initial release was something of a flop because of its use of Single Data Rate memory, the better-performing DDR version came shortly after.

4

GEFORCE 8800 SERIES

Release date: 2006

By 2002, the competition between Nvidia and ATI was fierce, leading to bigger and better boards. ATI pushed the envelope with its 200mm-size Radeon 9000 cards, but Nvidia laid down the gauntlet in 2006 with this 300mm beast. At $600, it was expensive, but also a true flagship with a performance that meant many owners held onto it for years after buying it. In the same year, AMD bought ATI.

3

GEFORCE GTX 680

Release date: 2012

By 2012, Nvidia was making high-end cards while AMD focused on the value end of the market, but both were racing towards producing a 28nm node. AMD got there first with its HD 7000 series but Nvidia blew it out of the water with the GTX 680, which was powerful but also reasonably priced at $500.

2

GEFORCE GTX 1080

Release date: 2016

The move to TSMC's 16nm process for the first Pascal cards was a huge deal. Architecturally, the card wasn't too different from the previous Maxwell design, but the leap in performance from 28nm to 16nm was huge. AMD, trying to leap to its own 14nm process, had no answer, leaving Nvidia to become the de facto graphics company for years.

GTX 1080
GEFORCE GTX

1

GEFORCE RTX 3080

Release date: 2020

The RTX 20-series was a disappointment, being only a little faster than the 1000-series, but with ray tracing and deep learning super sampling (DLSS), neither of which were quite ready for the mainstream. Thankfully, AMD brought some competition with its RX 5000 series, making Nvidia pull out the stops for the RTX 30-series, with a new Samsung 8nm process, better ray tracing, and DLSS 2.0.

© WIKIMEDIA

Jeremy Laird

TRADE CHAT

Nvidia's Lovelace letdown

IT WASN'T SUPPOSED TO BE this way. 2022 had all the makings of a stellar year for PC graphics, so good it would make up for the pandemic- and crypto-fueled bubble. Alas, Nvidia has kicked off the latest round of GPU launches with the RTX 40 Series, otherwise known as Lovelace. And it's a crushing disappointment. It's also worrying for AMD's upcoming GPUs.

Nvidia's new RTX 4090 board is a beaut. So is the AD102 GPU at its heart. Nvidia has not lost its technical touch, the 4090 is a major leap forward. The problem lies with the pair of so-called RTX 4080 boards. They are, in my opinion, trash. To understand why, let's go back to the launch of the Ampere RTX 30 Series two years ago. Then, Nvidia rolled out the impressive RTX 3080. It was a cut-down version of the RTX 3090 and used the same high-end GA102 chip with a few circuits fused off. The 3080 had roughly 80 percent of the functional units of the RTX 3090 for a fraction of the cost.

Meanwhile, the RTX 3070 got the then second-tier GA104 GPU and served up around 55 percent of the hardware of the 3090. With these Lovelace boards, it couldn't be more different. The RTX 4080 12GB model gets the AD104 GPU and makes do with a pathetic 45 percent of the 4090's functional units. We haven't got the full specs, but the 4080 has 7,680 shaders to the 4090's 16,384. For the 3080 and 3090, it was 8,704 shaders to 10,496.

The spec gap for Lovelace is so big, the relationship between the 4090 and the 4080 is more akin to that of the 3090 and the 3060 Ti. Except, the 3060 Ti at least got a 256-bit memory. Astonishingly, the 4080 12GB has a feeble 192-bit bus. That's right, a $900 graphics card with a 192-bit bus. What a joke. OK, the 16GB 4080 is 256-bit. But it's still nowhere near the 4090 overall.

Go back even further to RTX 20 Turing series, and the gap between the top few GPUs was a bit bigger than the RTX 30 series. But it was still nothing like the yawning chasm between the RTX 4080 and 4090. To take just one example, the RTX 2070 was well over half an RTX 2080 Ti by pretty much every measure of shaders, ROPs, textures, and VRAM allocation.

However, the metric that really drives home what a rip-off Nvidia is serving up involves bang for buck. Granted, the RTX 4090 is so pricey at $1,599 that only the most dedicated PC gamers can justify it. But it still ends up looking like a steal next to the RTX 4080. The cost in terms of dollars per shader and per GB of VRAM—and likely per ROP, texture unit, and the rest—is lower for the 4090 than the 4080. That is crazy!

Even worse, if this is how bad the 4080 12GB is going to be, what will the 4070 look like? And the 4060? I shudder to think how hobbled those GPUs will be. Could the 4060 have a 96-bit bus? You have to wonder at this point. Nvidia's choices also make me worry about AMD's upcoming GPUs. After all, the AD102 GPU is an absolute beast, all 76 billion transistors of it.

Had Nvidia made the RTX 3080 from a cut-down AD102, I wouldn't be saying any of this. But you can be sure that Nvidia knows exactly what AMD's upcoming RDNA 3-based Radeon RX 7000 Series GPUs look like. Yet it deemed these overpriced excuses for '80 Series graphics boards good enough.

I'm not expecting RDNA 3 to be this disappointing. But it now looks pretty much nailed on that the more pessimistic rumors will be accurate. Quite how it came to this I'm not sure. Nvidia clearly has the silicon to make a decent 4080 GPU. AMD likely has some great chips to come, too. I suspect both outfits had grand plans for this generation and could have executed them but, at the last moment, they blinked. I have my theories as to why, but that's a story for another day.

> If the 4080 12GB is this bad, I shudder to think how hobbled the 4070 and 4060 will be.

The new RTX 4090 is a beast, pity about the rest of the new Lovelace range.

© NVIDIA

Six raw 4K panels for breakfast, laced with extract of x86... Jeremy Laird eats and breathes PC technology.

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Synology Mesh
> Ubuntu shares
> Laptop drive failure

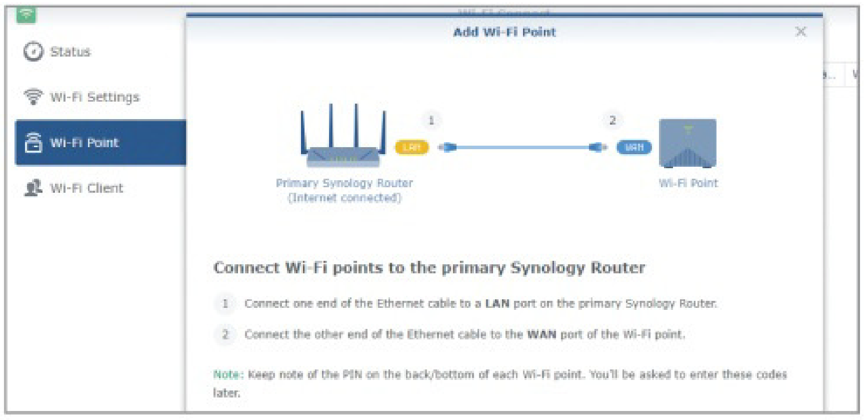
Synology Mesh setup

I'm a long-time user of a Synology RT2600ac router, and my biggest frustration has always been extending my Wi-Fi network to cover the whole house. I've experimented with extenders and a Powerline network with Wi-Fi, but having to prompt my devices to move from one network to another feels like a compromise.

Mesh networks would fix this problem, so you can imagine how excited I was to discover my RT2600ac could combine with other Synology routers to deliver such a solution. What do I need for such a setup—can I keep the cost to under $150, for example? And how do I go about configuring a Synology mesh network?

—Kevin Tuma

THE DOCTOR RESPONDS: You can create a simple two-device mesh network by combining your RT2600ac with either Synology's new flagship Wi-Fi router (RT6600ax, $301 newegg.com) or its budget WiFi 5 router (MR2200ac, $120 amazon.com). This should be sufficient to boost the signal to one dead spot in your home. You can then add extra MR2200ac routers as additional satellites should the need arise.



Connect Wi-Fi points to the primary Synology Router

1 Connect one end of the Ethernet cable to a **LAN** port on the primary Synology Router.

2 Connect the other end of the Ethernet cable to the **WAN** port of the Wi-Fi point.

Note: Keep note of the PIN on the back/bottom of each Wi-Fi point. You'll be asked to enter these codes later.

All of Synology's current router lineup support mesh.

If you chose the more expensive RT6600ax model, that would be the centerpiece of your new mesh network, and you'd need to reconfigure your RT2600ac as a satellite. However, by choosing the MR2200ac model to suit your budget, that becomes the satellite to your RT2600ac, which would remain as your primary router.

The key requirement for deploying the older RT2600ac and MR2200ac routers in a mesh environment is that they're both running the same version of SRM—1.2.5 or the latest version of Synology's firmware (SRM 1.3.1). Were you to pair either router with the RT6600ax, you'd need to upgrade them to SRM 1.3.1. There are other good reasons for upgrading to SRM 1.3.1 too, not least its support for VLANs, allowing you to segment network devices into separate, isolated networks for security reasons.

At the time of writing, SRM 1.3.1 is rolling out to both models in a staggered fashion, so if you've not yet received an alert that SRM 1.3.1 is available, navigate to Control Panel → System → Update & Restore to see if the automatic check finds it. If not, you can download the update manually from Synology (www.synology.com/en-uk/support/download), then apply it via the 'Manual SRM Update' button. The update takes around 10 minutes.

After purchasing your MR2200ac, you'll need to initialize it as a regular router alongside your RT2600ac. Log into the web interface and upgrade it to SRM 1.3.1, then restore it to factory settings via the same Update & Restore tab.

Once done, connect an Ethernet cable from one of your RT2600ac's LAN ports to the WAN port of your MR2200ac. Now, from your RT2600ac's web interface, open Wi-Fi Connect and select Wi-Fi Point. Click Add, select 'Connect with both wired and wireless Wi-Fi points' and follow the wizard. Make a note of the tips for deploying your mesh points after they have been set up, and power on the MR2200ac when prompted.

When the LED flashes blue, it's ready, so click 'Wi-Fi Ports Ready' and wait for it to detect the MR2200ac. You'll need to enter the latter's PIN code (on the back of the machine), then wait while your RT2600ac completes the configuration. The MR2200ac becomes a 'dumb' Wi-Fi access point that allows you to seamlessly extend your network without having to set up new network IDs or passwords. You'll be able to view its status from your RT2600ac's web interface under Wi-Fi Point.

You can now disconnect the MR2200ac from your main router's LAN port and

© SYNOLOGY

↘ submit your questions to: doctor@maximumpc.com experiment with placing it around your home for best effect. Wi-Fi Point will keep you updated as to the signal strength and recommend you move it, if necessary.

Visible Ubuntu shares

Is there a way of making my Ubuntu shared folders visible when browsing in Windows? I can address the share directly by typing \\SHARENAME into the Address bar of File Explorer, but it's frustrating I can't simply see the drive when I click the Network icon.

—Leonard Marquez

THE DOCTOR RESPONDS: Ubuntu's implementation of Samba relies on SMB 1.0/CIFS file sharing support in order to make its folders visible in Windows' Network view. SMB1 support was dropped by default in Windows 10 from version 1511 onwards. While you can switch the feature back on, it isn't recommended for security reasons.

You'd have thought Samba would have addressed this issue by now—indeed, an unimplemented patch dating back to 2015 can be found in the Samba bug tracker that would resolve the problem. But with no official fix forthcoming, Steffen Christgau has taken matters into his own hands and developed a workaround—wsdd (Web Service Discovery host daemon). This Python-based tool has finally been added to the official universe package repository for Ubuntu 22.04 and Linux Mint 21. If you're running either, install it with the following command:

```
sudo apt install wsdd
```

A dedicated repo exists for older versions of Ubuntu, Mint, and Debian, instructions for adding this can be found at the wsdd GitHub page (https://github.com/christgau/wsdd) where you'll find help for other OSes too, including macOS. Once installed, open Network in File Explorer on any Windows PC and your Samba shares should now be visible.

Mini Zen 4

Is it possible to upgrade a mini-ITX system with a 1U power supply to a Zen 4 system with Windows 11? I know it's a new system, but is there a possibility? Again, this would be a low-power upgrade with no video card.

—Daniel Serrano

THE DOCTOR RESPONDS: In theory, yes. Asus has already announced both micro-ATX and mini-ATX boards for AMD's Zen 4 Ryzen 7000 series—in your case, the Mini-ITX ROG Strix X670E-I Gaming WiFi will meet your setup's needs. All four Ryzen 7000 chips also come with integrated graphics (RDNA2 GPUs) to avoid the need to add a separate graphics card.

In terms of power draw, the two lower-end models, the Ryzen 7 7700X and Ryzen 5 7600X, draw a similar amount of power (105W TDP) to the previous-generation Ryzen 5000X series—significantly more than low-power systems but still less than the top-of-the-line models, the Ryzen 9 7950X and 7900X, which draw 170W TDP with a peak 230W. With this in mind, make sure your 1U PSU supplies a minimum of 500W (600W should offer a comfortable minimum with some overhead).

Aside from power draw, your main consideration will be space inside your existing case for such elements as cooling. Again, there's good news: CoolServer's new Zen 4 cooler product lines include low-profile models specifically targeting 1U servers, so even if you're using a non-1U case, they're still options. Two passive coolers potentially fit the bill: the AM5 1U1CA can dissipate up to 150W, while the SP5 1U-S11 radiator claims up to 260W.

To sum up, there is mini-ITX support for the new Zen 4 series—you'll need to upgrade the mobo, CPU, cooling, and RAM (to DDR5), and that will cost you a pretty penny—expect to pay over $1,250 for an entry-level system based around the Ryzen 5 7600X.

With that kind of investment, it pays to double-check all specs and measurements to ensure everything fits inside your existing case before you take the plunge. That said, if the case ends up being the stumbling block, you could always upgrade that too.

Asus has announced a Zen 4 mini-ITX board.

© ASUS

Drive failure query

I'm the owner of a Lenovo Legion 5i Pro laptop (2022 model). I swapped out the supplied Samsung Gen 4 1TB drive for a Samsung 2TB 980 Pro with a heatsink, as I wanted extra storage.

Unfortunately, after two months, the drive failed with no warning. I paid for Lenovo Premium Care to fit a replacement drive, then claimed for the damaged drive from Samsung direct. Although my data was backed up, I had to create a Lenovo boot drive to reinstall Windows from scratch. Any advice on how I can prevent this from happening again?

—Gregory J Kimbrell

THE DOCTOR RESPONDS: The Doc feels your pain. Going forward, you should be able to protect yourself from such pain with a few tweaks and a working backup regimen.

A quick glance at the hardware manual for the Legion 5i reveals its NVMe SSD slots are reasonably accessible, and that in this case there are two, allowing you to fit two drives simultaneously.

Assuming your laptop has two slots, the Doc would strongly recommend pressing your old Gen 4 1TB drive back into action alongside the replacement 2TB 980 Pro. This serves two purposes: the first is that it allows you to separate your data from your OS, so if the Windows drive fails, you won't need to restore your data backups.

The second is that the additional drive gives you the option of using it as a backup for your main drive—in this case, a regularly updated drive image taken using a tool like Macrium Reflect Free (www.macrium.com/reflectfree). Set up a backup regimen that mixes monthly full backups with weekly or daily differential backups and set limits to the number of backups to prevent them from taking up all your drive space.

In an ideal world, you'd use the existing 1TB drive as your boot drive, and the 2TB drive as your data/backup drive. Consider using Macrium to transfer the contents of your 2TB drive to the 1TB drive (space permitting), then enter the UEFI to make your 1TB drive the boot default. Once you've successfully booted from it, wipe the former then move your data from the old 1TB drive to the freshly formatted new one. Doing so alleviates any storage space issues you previously had with the 1TB drive.

In addition, the Doc recommends installing Samsung's Drive Magician (https://semiconductor.samsung.com/consumer-storage/magician/) to monitor the replacement Samsung drive. This should provide you with a tool to not just keep an eye on the drive, but also provide some form of early warning system. Finally, make sure you create the Macrium rescue media on a blank flash drive (512MB or larger will suffice). If the worst happens, you can be up and running in under an hour after fitting the replacement drive yourself—no more Lenovo engineer callouts required.

AMD BRILLIANCE FOR UNDER $1,000

Following our budget Intel build, *Sam Lewis* tries the AMD route

AFTER FEATURING a sub $1K Intel machine in last month's issue, it's only fair to turn our attention toward Team AMD and see what we can build for the same amount of money. This battle of the two main CPU competitors has left us changing teams constantly. We've twisted and turned about which is the better of the two, but there will always be a place in the market for both to coexist.

In the driving seat for this build, we have the AMD Ryzen 3 3100 CPU. We're putting our faith in this budget-end processor to deliver a smooth 1080Pp gaming experience alongside an MSI GeForce RTX 3050 GAMING X 8G GPU.

As far as looks go, we're starting strong with Corsair's iCUE 220T RGB Airflow case. This mid-tower chassis certainly gives off a more premium appearance than its price tag might imply. That's what we want here, not just a PC for under $1K that can perform well enough to comfortably play games at 1080p, but also one that looks the part too. Hopefully, with this chassis, we can do just that.

When building toward a specific price tag, we have to spread our components out equally. We can't buy a huge GPU and have a CPU equivalent to a 2010 smartphone. As interesting as that sounds, it'd be like putting a lawn mower engine in a Ferrari chassis and expecting it to perform.

We hope that we've matched our components to create a well-rounded machine that can be used for work, socializing, and gaming. And we're going down the AMD route with a build costing under $1K. So, let's get our hard hats on and start building.

BUILD IT PG. 23

AMD
XLR8
WD_BLACK
FORCE RTX

INGREDIENTS

PART		STREET PRICE
CPU	AMD Ryzen 3 3100	$149
GPU	MSI GeForce RTX 3050 GAMING X 8G 8GB GDDR6	$299
MEMORY	32GB (2x 16GB) PNY XLR8 Gaming REV RGB DDR4-3200	$110
MOBO	Asus TUF GAMING B550M-Plus (Wi-Fi) Micro ATX AM4	$140
SSD	1TB WD_BLACK SN70 w/ Heatsink PCIe 3.0 NVMe SSD	$110
PSU	Be Quiet! System Power 9 500W 80+ Bronze PSU	$55
CPU COOLER	AMD Wraith Stealth	$N/A
CASE	Corsair iCUE 220T RGB Airflow Mid Tower	$100
OS	Windows 11 Home 64-bit OEM	$32
TOTAL		$995

PRICES CORRECT AT THE TIME OF PRINTING

CPU $149, www.amd.com

• AMD RYZEN 3 3100

In terms of bang for your buck, this budget-end AMD Ryzen 3 3100 chip may not be the best around, but it is a great entry-level processor. Just shy of $150, it fits the bill for our mission objective here. We get four cores with eight threads and a maximum turbo frequency of up to 3.9GHz in this CPU.

It doesn't feature integrated graphics but this isn't an issue because we're pairing it with a dedicated graphics card. It also uses AMD's Zen 2 architecture showing the age of this CPU, however, it still stands strong as a great value-for-money CPU with a reasonable performance.

GPU $300, www.msi.com

• MSI GEFORCE RTX 3050 GAMING X 8G

This GPU sits at the bottom of Nvidia's 30 series GPU hierarchy, but should not be ignored. With a sale taking it down to the $300 mark, this graphics card is superb value for money. It's got 8GB of DDR6 memory and is built on Nvidia's Ampere architecture.

It also features some neat cooling performance, with TORX 4.0 fans that aim air into the TWIN FROZR 8 cooling system and a silencing heatsink design. This helps make the GAMING X 8G run smooth and quiet too. With this GPU, we expect reliable 1080p gaming at a smooth frame rate with decent graphical settings applied. We'll test whether we can run our settings on ultra but, for this price, we'd be happy running on medium to high.

BUILD IT PG. 23 ⇨

MOTHERBOARD **$140, www.asus.com**

• ASUS TUF GAMING B550M-PLUS (WI-FI)

Another component that sits under the $150 price mark is our motherboard. This Asus Micro-ATX board will fit neatly in our compact case, allowing for plenty of space around to work with.

Despite its smaller dimensions, this board is more than what we need for this machine. It has plenty of functionality, including BIOS FLBK support for an easier setup. It also supports Zen 3 architecture and, although our chip doesn't fit into this bracket, it's nice to have additional support there in case we decide to upgrade the CPU in the future.

The TUF GAMING B550M-Plus (Wi-Fi) also supports PCIe 4.0 connectivity, USB 3.2 Gen 2 Type-A, Type-C, and Wi-Fi 6.0 support, which is great for our little machine.

STORAGE **$110, www.westerndigital.com**

• 1TB WD BLACK SN750 W/ HEATSINK PCIE 3.0 NVME SSD

If you only have one option for a storage solution in your build, M.2 SSD is the best choice to make. Although this doesn't feature PCIe 4.0, as our CPU and motherboard can support it, this drive is still a speedy component with enough capacity to start off with.

At 1TB, this is more than enough for a varied gaming library while also having the performance to boot these titles quickly. This can be improved when using the WD_BLACK SSD Dashboard application. When enabling the gaming feature in the software, it allows for the SSD to run at full force by disabling the low power mode. This should get us to the claimed read speeds of up to 3,430MB/s and write speeds of up to 2,600MB/s.

WD_BLACK
SN750

GET READY TO BECOME A TRUE PYTHON EXPERT

Make Python work for you with tutorials on coding with Django, Flask, Pygame
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BUILD IT PG. 23 ⇨

RAM $110, www.pny.com

• PNY XLR8 GAMING REV RGB 32GB (2x 16GB) 3200MHZ DDR4

Running at a speed of 3200MHz and with a CL16 CAS latency, this RAM kit from PNY is perfectly fast enough to make its way into our AMD budget machine.

It's a 32GB kit consisting of two 16GB DIMM sticks. Again, this is more than enough for what we need here, making it ideal for future-proofing purposes. These sticks support XMP 2.0, so if we wanted to get some extra performance gains, we can apply some memory overclocking in the BIOS. These are sleek DIMM sticks that should fit the black aesthetic of the rest of the build by matching our black chassis and motherboard. The RGB design style is a clean, smooth transitional cycle that should hopefully pair up nicely with the RGB fans in the front of our Corsair 220T RGB Airflow case and the subtle RGB on our MSI GeForce RTX 3050 GPU.

CASE $100, www.corsair.com

• CORSAIR iCUE 220T RGB AIRFLOW

Housing all of our components together is our chassis. This specific model is Corsair's iCUE 220T RGB Airflow. This mid-tower case is a compact product featuring the majority of characteristics needed for a good case.

As well as having stylish good looks, this case has plenty of functionality, compatibility, and cable management features. The case also has a 35 percent smaller volume than a 'typical' mid-tower case, which gives it a smaller footprint on your desk.

It's no secret we love cases that feature a good airflow system, and the name here implies just that. The front panel features arrow-like cutouts that allow for air to be drawn right through the case.

To help airflow even further, it also features three SP120 RGB pro fans at the front. As well as being powerful and quiet, these fans add a smooth glow that shines out the front of the cutouts as well as lighting up the inside of the case.

CPU COOLING **$N/A, www.amd.com**

• AMD WRAITH STEALTH COOLER

Unlike Intel, AMD has long had the stock CPU cooler game nailed. Indeed, it took until Intel's 12th generation to create a decent-looking stock cooler that could challenge the likes of AMD's Wraith cooler range.

For our build, we've chosen the standard version, aka the Stealth, that came with our AMD Ryzen 3 3100. You can't go wrong with a free cooler.

Of course, if we were using a more powerful GPU within this build and if our airflow wasn't as good, we may have opted for a larger AIO cooler instead.

However, this stock cooler helps keep our budget below the target $1,000 mark.

PSU **$55, www.bequiet.com**

• BE QUIET SYSTEM POWER 9 500W 80+ BRONZE PSU

Last but not least, we have arguably one of the most important components to keep the machine in working order, our PSU. Courtesy of Be Quiet!, we have chosen the System Power 9 500W to make its home in the bottom of our Corsair chassis. You don't need to spend a fortune finding a solid and dependable power supply to power your rig.

Thankfully, a sale has made this a good pickup at the time of building this machine, but you can easily pick up an 80+ rated PSU for under $100.

This is a semi-modular design that runs quietly too, with enough wattage to keep things under control.

ALL YOU NEED FOR JUST UNDER $1K

IS STICKING WITH AMD THE BEST CHOICE FOR OUR BUDGET-GAMING MACHINE?

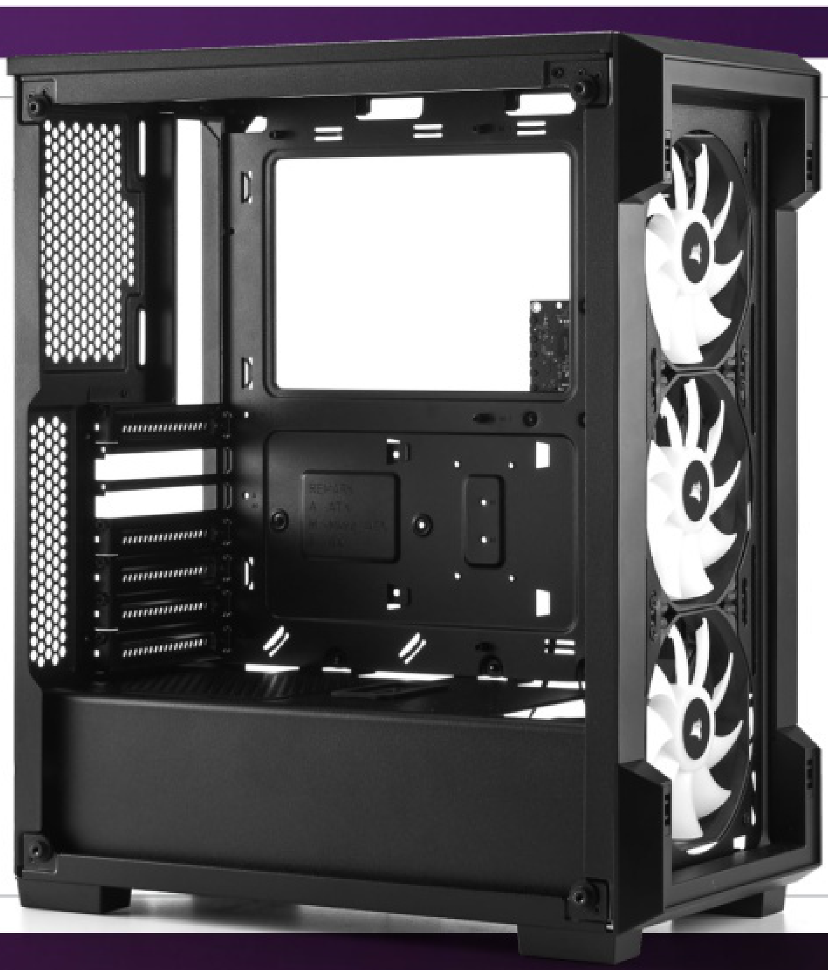
LENGTH OF TIME: **1-2 HOURS**

LEVEL OF DIFFICULTY: **EASY**

1 DOWN TO BUSINESS

TO MAKE LIFE EASIER for ourselves, we start by stripping down our PC case before we begin building in it. This way we can truly see what we are working with, how to plan out the rest of the build, if there may be any hurdles to overcome, and generally make the build easier.

This Corsair iCUE 220T RGB Airflow case isn't the smallest we've worked in, but it's still a compact design for an ATX mid-tower chassis, so taking it apart is a must. This is made easy with a front panel that pulls straight off and a glass panel that contains four large thumbscrews. The back panel contains screws too, but it slides off easily after loosening them. As for the three SP120 RGB pro fans, we're leaving them in as they came from Corsair.



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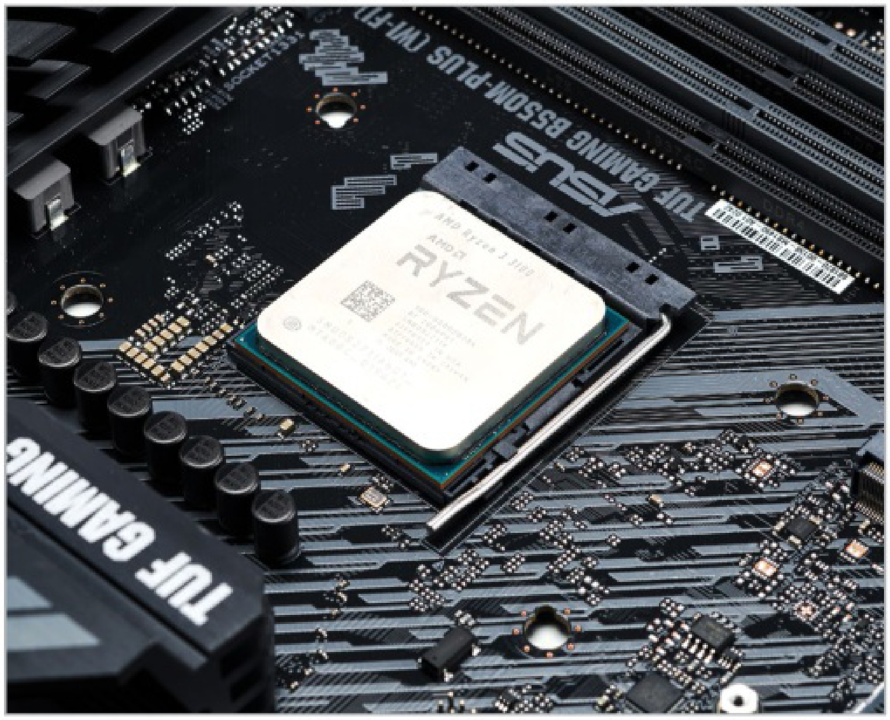
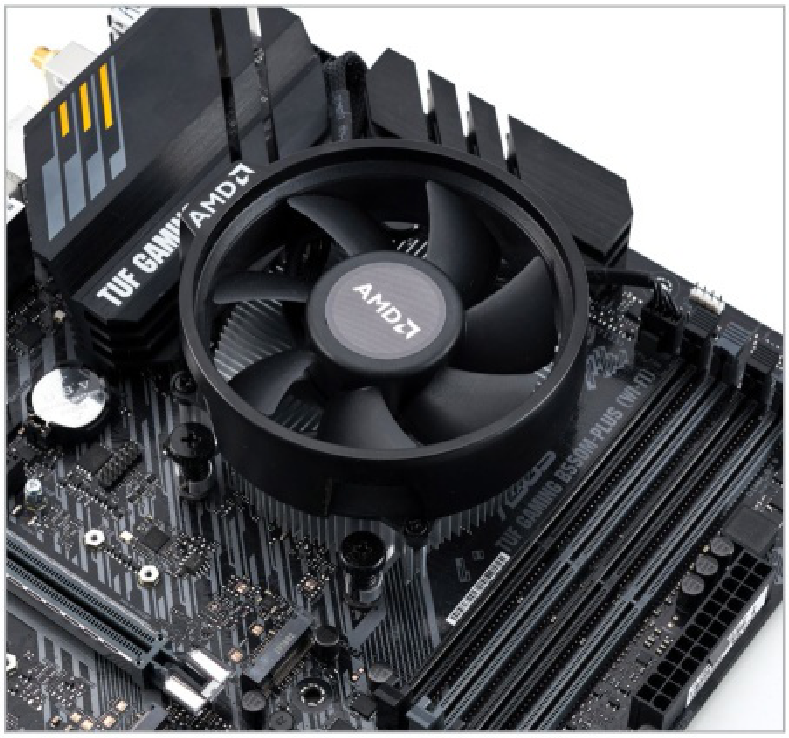
2 THE CAPTAIN IS ONBOARD

LEAVING THE CASE alone until later on, we bring out our motherboard to start installing our components onto it, the first of which is our AMD Ryzen 3 3100 CPU. We have to be honest here—we had a small hurdle to overcome already at this stage. Unfortunately, when unboxing this processor, a few pins on the CPU were slightly bent, resulting in a short-lived but very real panic and a bit of on-the-spot thinking.

Using a thin bank card, we ran this along the rows of untouched pins to straighten the bent ones. This alignment thankfully worked but we had to be extremely careful. It was still hit or miss whether the CPU would be fine. Anyway, to install it, we needed to lift up the retention arm on the motherboard to reveal the AM4 socket. Then, we grabbed the sides of the processor to make sure not to touch the pins, which is important.

Make sure the little arrows on both the socket and the CPU point to each other and rest the CPU down. Finally, bring the retention arm back into position and this will secure the CPU down into the motherboard.





3 COOLING DOWN PERIOD

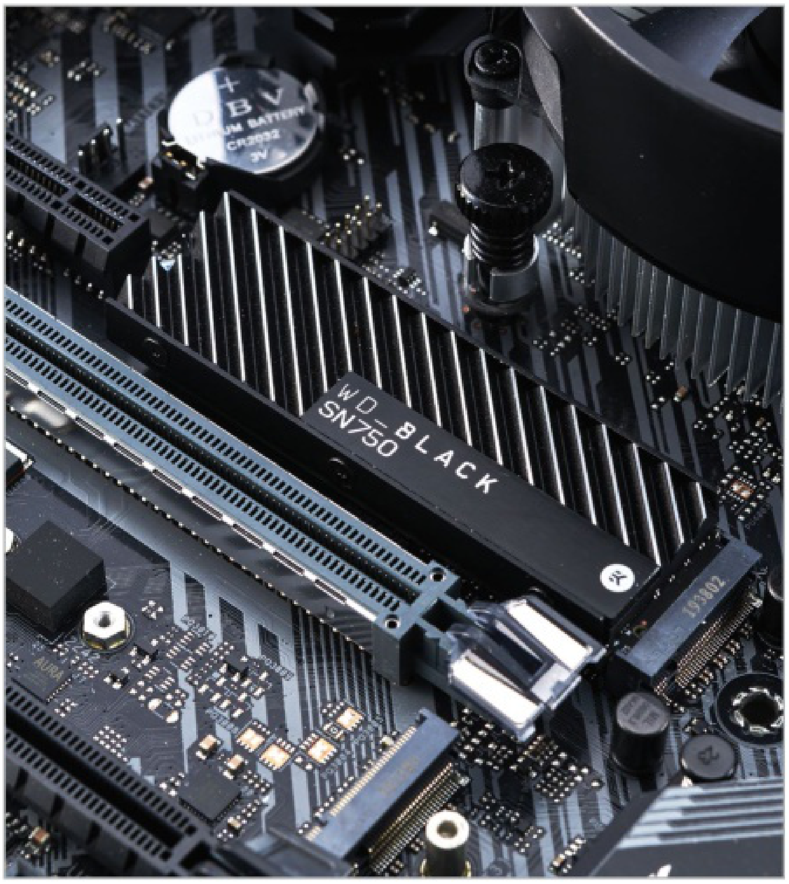
AFTER A CLOSE CALL with the main brain of the build, the least we could do is provide a bit of cooling. Stock coolers are some of the easiest to install, especially the AMD ones—all that was required was a backplate for the cooler and some thermal paste.

Our backplate was a fixed item that simply lined up with the motherboard's holes, nothing more to it than that. Then, after applying a pea-sized amount of thermal paste onto the center of our CPU, we gently place the Wraith Stealth on top, making sure the screws from the cooler fit into the screw holes of the backplate. Then tightening from one corner to the diagonal corner one bit at a time, we evenly tightened it down on the CPU.

4 LOCKING DOWN THE STORAGE

EVEN EASIER THAN INSTALLING our stock cooler is installing our SSD. If you thought tightening four screws was a walk in the park, how about just tightening one? On the flip side, the single screw here is an absolute nightmare to find if you drop it, so try not to do that.

Anyway, to get this installed, use the uppermost M.2 slot on your motherboard and, at a 30° angle, insert the SSD into the port. Then rest it down to align the notch of the SSD with the screw hole. After that, you'll need to use a small Phillips screwdriver to tighten the tiny screw into position.



5 DIMM O'CLOCK

AFTER OUR SSD, it's time to get our RAM added to the board. Before we get our hands on the physical RAM, we have to work out which DIMM slots we'll be taking, because we won't be using all of the four slots available to us with our kit. Taking a look at the motherboard's manual, we figured we needed to use slots 2 and 4. To install, open up the necessary clips on the board then line the notch in the slot up with the notch on the DIMM sticks. Then push down the sticks until they click into position.

6 FILLING THE CASE

AFTER ALL OUR MOTHERBOARD components are installed, aside from the GPU, we can bring this into the case. As our board is a micro-ATX form factor, we need to make sure that the standoffs in the case are in the right position. Wherever there is a letter 'M' indicated on the board, that's where there the standoff needs to be. You can use a standoff socket, found in a PC toolkit, to loosen and move the standoffs from the usual ATX position to the micro-ATX position.

After that's done, we need to make sure that the I/O shield is popped into the I/O position in the case, and then finally, we can line our motherboard up into position inside the case. When doing this, we always recommend laying the case down on its back. Once aligned, we can add in all of the screws and tighten them in a diagonal fashion to ensure equal pressure when securing it down.

7 GRAPHICAL POWER TIME

IF ANY OF YOU eagle-eyed readers had noticed, we actually preempted this step and removed the second and third shrouds in our case strip down at the start. Luckily, it's usually these ones that have to make way for the GPU's ports and it was the case in this build. These are attached via a single screw each so removing and installing these is a breeze.

Like installing the RAM, we need to open the clip on the port to make way for our component. Choose the uppermost PCIe port to do this on. Then insert the GPU and push it down to click it into position. To secure it further, you'll need to use the screws from the removed shrouds to tighten it to the case.

8 BRINGING IN THE PSU

WITHOUT THIS, all our hard work would be pointless and our machine would be powerless. Thankfully, we aren't going to put this on the mantelpiece and, instead, we need to add it to the bottom of our case. Take the PSU and make sure the fan is aimed toward the bottom. Align the screw holes with the case and tighten them into position, again working diagonally.

If you aren't using an HDD, it's always handy to remove the cage at this point to make way for any excess cables. This will help you out when tidying the build at the end.

9 THE PSU'S VEINS

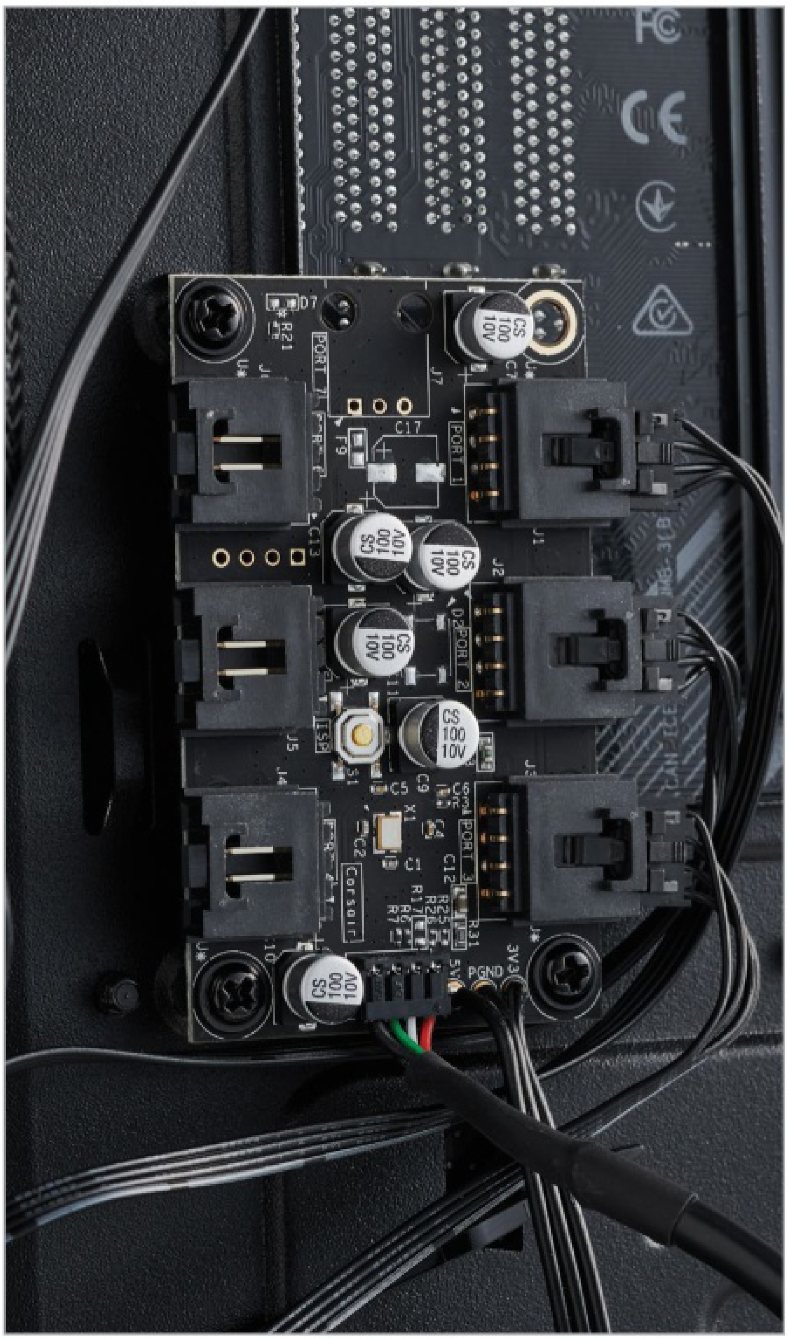
NOW OUR PSU is hooked up to the case, we must connect it up to the motherboard. We only need four cables from our PSU in this build, one each for the CPU, GPU, the Corsair lighting node core, and the 24-pin motherboard cable. As it's a semi-modular design, the 24-pin and CPU cables are attached and so we installed these first. The CPU cable almost always connects at the top left of the motherboard so it can be tricky to get in, especially if you don't have much room. The 24-pin cable is slightly easier and can be fed through one of the case's rubber channels. As for the other two cables, these are modular. We need a PCIe for the GPU and a Molex to power the case's lighting node core.

10 THE FINAL WIRES

WE'RE GETTING CLOSE to the finishing line, but we now need to connect all of the front panel case cables and fans both to the motherboard and the lighting node core as well as some mandatory cable management. That seems like a lot, but once you've done this a few times it becomes easier. Always refer to your motherboard's manual to see where to install the front panel power cables as if they're single-pin connectors, this can get fiddly, as it was in this build.

The USB connectors were easy to install, as was the audio connector. Our problems began when it came to the fans. First, we had only two available fan headers and three fans, so in came a spare daisy chain we found in our stock room. After that was sorted, we had power to our fans but no RGB. This was because we installed the RGB cables in random order in the Corsair lighting node core.

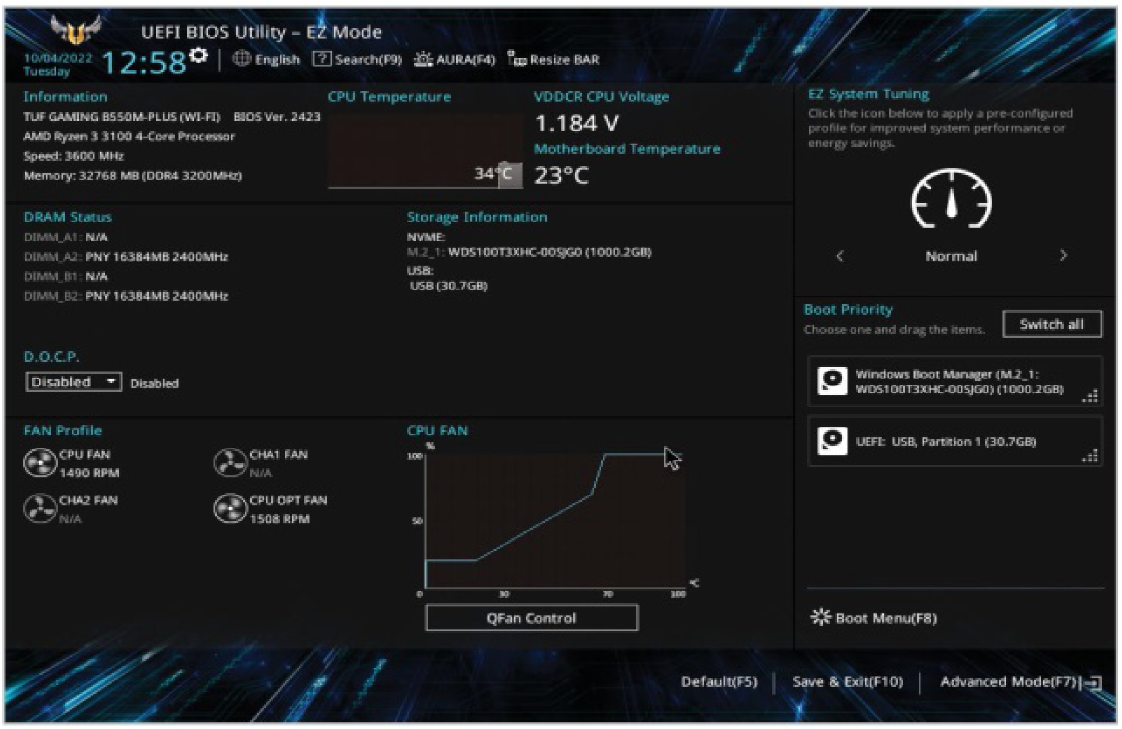
After glancing back at the manual of the case, we realize that the fans have to be in an ordered sequence. For example, the top fan had to go in slot 1, the middle in slot 2, and the bottom in slot 3. We initially had them in 4, 5, and 6, resulting in no lighting. After we figured this out, we successfully managed to get our fans working with the accompanying RGB glow.



11 UPDATING OUR BIOS

IT'S ALWAYS ADVISABLE to update to the latest version of your BIOS before going any further. Using another PC, head to the motherboard manufacturer's page and go to the support section. In here, you'll find the latest version of the BIOS. Download this onto a clean USB drive that's formatted to FAT32.

Then insert this into the 'BIOS' USB port and boot your PC. When the motherboard's logo appears, hit the 'F2' or 'DEL' key until it boots into the BIOS. Inside the BIOS, go to the Asus EZ Flash 3 Utility within the tools section. Next, in the 'drive' field, find and select the USB drive with the BIOS update on it, then find the file and hit enter. Reboot once the update is complete.


UEFI BIOS Utility – EZ Mode
10/04/2022 Tuesday 12:58

Information
TUF GAMING B550M-PLUS (WI-FI) BIOS Ver. 2423
AMD Ryzen 3 3100 4-Core Processor
Speed: 3600 MHz
Memory: 32768 MB (DDR4 3200MHz)

CPU Temperature: 34°C

VDDCR CPU Voltage: 1.184 V

Motherboard Temperature: 23°C

EZ System Tuning
Click the icon below to apply a pre-configured profile for improved system performance or energy savings.
Normal

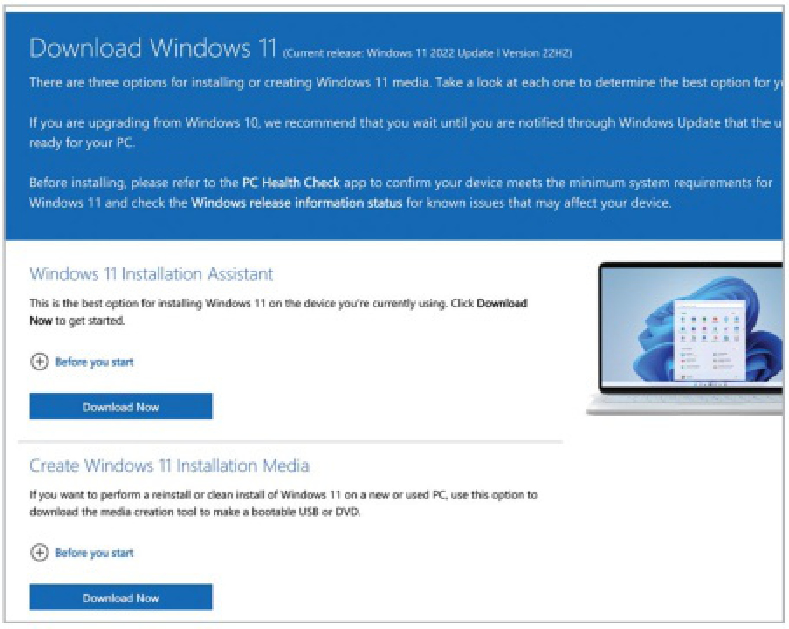
DRAM Status
DIMM_A1: N/A
DIMM_A2: PNY 16384MB 2400MHz
DIMM_B1: N/A
DIMM_B2: PNY 16384MB 2400MHz

Storage Information
NVME:
M.2_1: WDS100T3XHC-00SJG0 (1000.2GB)
USB:
USB (30.7GB)

D.O.C.P.
Disabled Disabled

Boot Priority
Choose one and drag the items.
Windows Boot Manager (M.2_1: WDS100T3XHC-00SJG0) (1000.2GB)
UEFI: USB, Partition 1 (30.7GB)

FAN Profile
CPU FAN 1490 RPM
CHA1 FAN N/A
CHA2 FAN N/A
CPU OPT FAN 1508 RPM


Download Windows 11 (Current release: Windows 11 2022 Update I Version 22H2)

There are three options for installing or creating Windows 11 media. Take a look at each one to determine the best option for y

If you are upgrading from Windows 10, we recommend that you wait until you are notified through Windows Update that the u ready for your PC.

Before installing, please refer to the **PC Health Check** app to confirm your device meets the minimum system requirements for Windows 11 and check the **Windows release information status** for known issues that may affect your device.

Windows 11 Installation Assistant

This is the best option for installing Windows 11 on the device you're currently using. Click **Download Now** to get started.

Create Windows 11 Installation Media

If you want to perform a reinstall or clean install of Windows 11 on a new or used PC, use this option to download the media creation tool to make a bootable USB or DVD.

12 INSTALLING THE OS

WE'LL BE USING WINDOWS 11 on this machine now that we have the latest BIOS version successfully installed. Again, we will need another system and a clean FAT32 USB drive. Make your way over to the media creation page on Microsoft's official website. Click download where it says 'Create Windows 11 Installation Media'. Open this and follow the on-screen installation instructions. Once you get to where you need to install the media, find and select your clean USB drive.

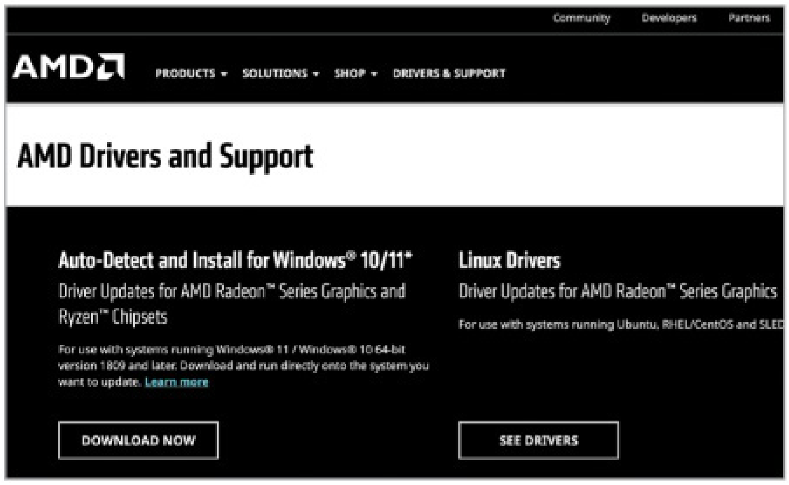
After the installation has finished, insert the USB into your new build and boot up the BIOS. Head over to boot priority and make sure that you rearrange it to make your USB drive the priority. Save this and exit the BIOS to reboot your system. This should take you to the Windows 11 installation process that you need to run through in order to set up your new PC.

13 ILLUMINATED POWER SUPPLIES

AS WELL AS getting the latest OS and BIOS for our system, we also need to make sure that all of our drivers are up to date. An easy way to do this is by installing the AMD Auto Detect and Install program. This can be found on AMD's website under the drivers and support section.

Here, you just need to hit download for the Windows 10/11 application and follow the installation instructions. It will make sure your Ryzen processor has the latest chipset driver installed. It will also update your drivers on your Radeon GPU but seeing as we have an NVIDIA card, we need to download the GeForce Experience application to update our RTX 3050 drivers there.

After these, it's also worth heading back to the Windows Update section in the OS settings and checking to see if there are any additional optional updates to complete. If there are, install what is available and restart your machine afterward. By this point, you should be ready to start going on an installation spree of your favorite games and applications. To make this stage even easier, head over to www.ninite.com, select the apps you want and this will do all the hard work for you in one go.


AMD Drivers and Support

Auto-Detect and Install for Windows® 10/11*
Driver Updates for AMD Radeon™ Series Graphics and Ryzen™ Chipsets
For use with systems running Windows® 11 / Windows® 10 64-bit version 1809 and later. Download and run directly onto the system you want to update. Learn more

Linux Drivers
Driver Updates for AMD Radeon™ Series Graphics
For use with systems running Ubuntu, RHEL/CentOS and SLED

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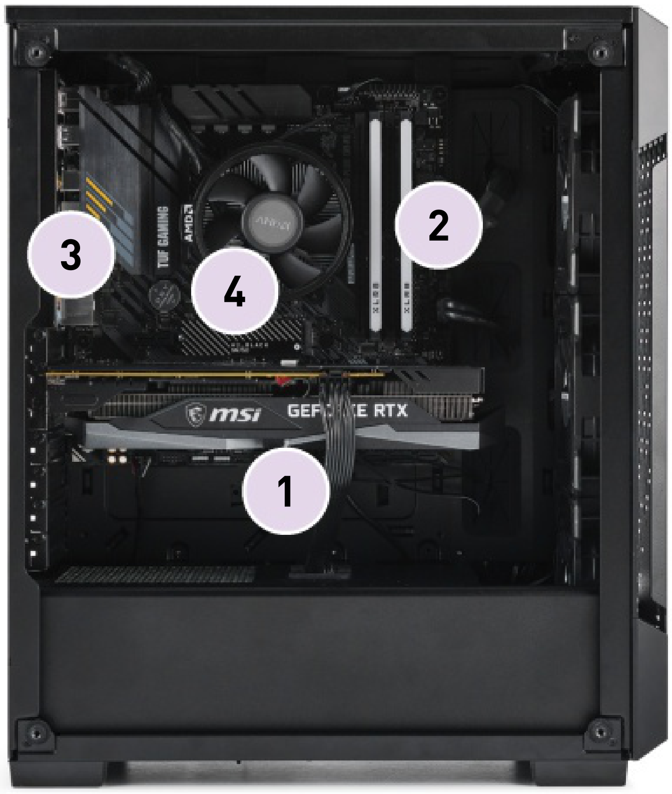
GOAL ACHIEVED?



1 To improve our overall tidiness, a cable comb on our PCIe cable would have helped keep this vertically straight.

2 Although we were sticking to a budget, we'd have liked to get a kit of RAM with four sticks to use here.

3 The airflow for this build is pretty impressive, however, an exhaust fan out of the back could further improve this.

4 Again, to improve the system's cooling, we could upgrade to a liquid-cooled AIO down the line.

SO, EVERYONE, we've made it to the finish line and can start to enjoy our newly built AMD budget-end machine. This is always the part when you can let out a sigh of relief as you know all of your time and hard work has paid off.

For this build, it was slightly nervewracking, as we were praying that the CPU worked. Thankfully, it did. Of course, avoid bending pins completely, but if you manage to get into the same position we did, your trusty bank card could do the trick for you. This made the rest of the build more nerve-wracking as we were unsure if this thing would ever boot up, but luck was on our side.

The only other hurdles we had when piecing this machine together were the fans and the RGB lighting. Problem number one was a lack of fan headers. We weren't exactly planning on only using two out of our three Corsair SP120 RGB pro fans, so we had to dig around in our stock room to find a spare daisy chain. We connected this up to the top fan header and then fed our three fan cables into this daisy chain connector.

As for our second problem, this occurred when we stuck the RGB cables into the fourth, fifth, and sixth ports of the lighting node core on the back of the case. Without thinking about it, we were left scrambling trying to figure out why we had no lights. It turns out, these needed to be in a sequence. The lesson here is to always check through your manuals. As much as we like to think we don't need them, they are always right.

Other than our CPU and fan issues, the rest of the build went very smoothly. Sure, there were a few times when it was a tight squeeze trying to get the cabling in place, but that was down to the compact nature of this case. These budget-end PCs are typically easier to put together than a larger machine with a liquid-cooled AIO, for example. It's definitely a great place to start if you're building your first machine.

So, the physical build itself was a success, but did we achieve our goal when it came down to the performance? In short, we were close enough. We wouldn't recommend running a game at ultra settings if it's not making at least 60fps. We'd usually prefer to run the graphical settings slightly lower to achieve a happy medium where we have a nice smooth refresh rate too.

As you can see from the table below, our results didn't quite make the 60fps mark when running games at ultra settings, so to achieve this, we would advise running them at medium to high settings to get a more stable 1080p gaming experience. The bottom line is that you can achieve this using this PC, just not at the maximum settings, but hey, that's why we carry out these tests.

Our CPU benchmarks were slightly lackluster, although this isn't the newest chip on the block. Saying that, using this machine for day-to-day activities and work was an absolute breeze—it's no slow coach at all.

BENCHMARKS

	ZERO-POINT	
Cinebench R23 Single-Core (Index)	1,537	1,135 (-26%)
Cinebench R23 Multi-Core (Index)	10,632	5,870 (-45%)
CrystalDisk QD32 Sequential Read (MB/s)	3,287	3,454 (5%)
CrystalDisk QD32 Sequential Write (MB/s)	2,419	2,996 (24%)
3DMark Fire Strike (Index)	24,814	13,515 (-46%)
Cyberpunk 2077 (fps)	68	55 (-19%)
Cyberpunk 2077 RTX (fps)	18	30 (67%)
Metro Exodus (fps)	75	46 (-39%)
Metro Exodus RTX (fps)	52	34 (-35%)
Total War: Three Kingdoms (fps)	72	53 (-26%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our 1080p zero-point consists of an AMD Ryzen 5 5600X, an XFX Speedster QICK308 Radeon RX 6600 XT, an Asus ROG Strix B550-F WiFi, 16GB of XPG Gammix D45 DDR4-3200, and a 1TB ADATA Legend 840. All games tested at 1080p 'Ultra' graphics presets with DLSS/FSR and V-sync turned off. XMP/AMP for RAM speed turned on in all tests. No manual CPU overclocking.

WHICH CPU ROUTE SHOULD YOU TAKE FOR A SUB $1K, 1080P GAMING RIG?

ARE YOU TEAM AMD OR TEAM INTEL?

IT'S ONE OF those age-old debates, similar to that of left or right, red or blue, even chocolate or vanilla ice cream. Yes, we are talking about AMD vs Intel? As we said earlier, we built a similar machine in the previous issue of the magazine for the same budget of just under $1,000. The challenge was to build a PC that ticked the 1080p gaming box, looked more premium than the actual cost, and was capable of being a reliable workhorse. We took that challenge and applied it to both Team AMD and Team Intel.

In both rigs, we managed to achieve two impressive machines that came in at just under $1,000. Of course, there are lots of characteristics and factors that can swing your decision in favor of either machine but, at this price point, which team should you side with?

DESIGN CHECKBOXES

Starting with designs, we feel both machines tick the box for looks, but the AMD machine takes a narrow win here. Both cases are great chassis for the price, offering good build quality, plenty of cable management solutions, support for multiple motherboard sizes, and premium aesthetics.

They are both front-ventilated cases too, making them good for heat dissipation and airflow. The Corsair offering in the AMD machine does have a trick up its sleeve, and that's a smattering of RGB. We know it's not for everyone, but you don't always have to choose a full rainbow splurge if you'd prefer something a bit more subtle.

Internally, we think that the AMD machine is a tidier and sleeker build. Visually, the components work better in synergy, though this could be down to the fact that they're mostly black. It givesthis machine a stealthy look when it's dormant, but when you boot it, it has splashes of RGB that make it feel like a more expensive machine. Although Intel has vastly improved its stock cooler, it still features a splash of blue, which may not go with other components. We also think that the RTX 3050 from MSI in the AMD machine looks more premium than the Zotac offering in the Intel PC. That gives the AMD build the edge in terms of visuals at this price point.

However, while looks are important, what we are really interested in, above all, is how these two budget rigs perform. Taking a quick look at our machines reveals quite the split in what to expect from each. Starting off with CPU power, it's clear that the newer Intel i5 12400 is the choice you should make if you're after a more future-proofed rig. It practically doubles the score on our Cinebench R23 Multi-core index, although there's a far closer outcome in the single-core performance. Our SSD is also knocked out of the park by the ADATA XPG GAMMIX S70 used in the Intel machine, so if you could choose between the two, we would opt for that SSD.

Meanwhile, for gaming performance, the AMD machine's combination of the Ryzen 3 3100 and the MSI GeForce RTX 3050 marginally outdoes Intel's valiant efforts. Though both systems won't get you consistently over 60fps on ultra settings at 1080p, they will provide you with a consistent 60fps plus, especially if we dial down the graphic settings to mid or high. It's our preference when choosing between frames and graphical detail anyway.

All in all, these are two evenly-matched setups coming in at just under the $1,000 mark. Although AMD slightly beats it in gaming, it wasn't a large enough gap to justify it over the Intel machine when it came down to overall performance. So, if the pricing is nearly the same, AMD wins on visuals and Intel wins on performance, which would appear to make it a draw.

Unfortunately not for AMD, as we are going to have to give this particular crown to team Intel. Performance matters a little more than aesthetics and although they were close in gaming, the CPU and SSD performance was better, providing greater longevity for the Intel rig. Regardless of which route you take though, there are many different combinations you could create to make it your own—indeed, that's the beauty of PC building. Have fun! ⏻

NZXT
msi
FORCE RTX
AMD
XLR8

BENCHMARKS

	INTEL BUILD	AMD BUILD
Cinebench R23 Single-Core (Index)	1,675	1,135 (-32%)
Cinebench R23 Multi-Core (Index)	11,735	5,870 (-50%)
CrystalDisk QD32 Sequential Read (MB/s)	7,100	3,454 (-51%)
CrystalDisk QD32 Sequential Write (MB/s)	6,775	2,996 (-56%)
3DMark Fire Strike (Index)	14,260	13,515 (-5%)
Cyberpunk 2077 (fps)	49	55 (12%)
Cyberpunk 2077 RTX (fps)	28	30 (7%)
Metro Exodus (fps)	44	46 (5%)
Metro Exodus RTX (fps)	33	34 (3%)
Total War: Three Kingdoms (fps)	63	53 (-16%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our 1080p zero-point consists of an Intel Core i5-12400, an Zotac GeForce RTX 3050 Twin Edge 8GB, an ASRock B660M-ITX/ac, 16GB of Corsair Vengeance RGB RS DDR4-3200, and a 1TB ADATA XPG GAMMIX S70. All games tested at 1080p 'Ultra' graphics presets with DLSS/FSR and V-sync turned off. XMP/AMP for RAM speed turned on in all tests. No manual CPU overclocking.

GEFORCE RTX
PALIT
GameRock
TUF GAMING
ASUS
GIGABYTE

Partners including Asus, Colorful, Gainward, Galaxy, GIGABYTE, INNO3D, MSI, Palit, PNY, and ZOTAC will soon sell custom cards using their own unique designs and cooling solutions.

© NVIDIA

Potentially the biggest jump in generational GPU performance ever

NVIDIA'S ADA LOVELACE ARCHITECTURE

IN A TEASER leading up to the Ada Lovelace and RTX 40-series announcement, Nvidia had a phone number asking, "Tell us, how fast do you want to go?" Perhaps KITT—that's the 'Knight Industries Two Thousand', if you weren't around in the 1980s—has finally arrived in the real world, except now he's a GPU instead of a souped-up Pontiac Trans Am. If you want to take Nvidia at its word, the apparent answer is two to four times faster than the RTX 3090 Ti.

However, there are a lot of caveats with those claims. In some scenarios, like with the new DLSS 3 algorithm and running extreme levels of ray tracing, that four-times difference in performance between the current generation RTX 3090 Ti and the RTX 4090 might materialize. In more typical gaming scenarios, especially without DLSS 3, we expect the gains to be smaller, but still substantial.

We're going to take a deep dive into everything that makes Nvidia's new RTX 40-series graphics cards tick. We have specifications on the first three announced models and their respective GPUs, access to the RTX 4090, and a whole load of technical documents. We also need to discuss pricing, the current GPU oversupply situation, and the end of Moore's Law. So get comfortable, grab your favorite beverage, and let's meet Ada Lovelace. **–JARRED WALTON**

DIALING UP CORE COUNTS AND CLOCK SPEEDS

Fundamentally, a big part of what makes a GPU fast comes from the core and clock speeds. With CPUs, there are lots of other factors to consider and scaling to higher core counts quickly starts to deliver diminishing returns. Graphics workloads are another matter, where scaling from dozens to hundreds to thousands of processing pipelines over the past two decades has generally resulted in directly proportional boosts in performance.

Check our Speeds and Feeds sidebar (below) for the raw specs of the three announced Ada Lovelace GPUs, though bear in mind that the announced cards have slightly different specs than we're showing. We have a full review of the RTX 4090 on page 74 (spoiler: it's good), and the RTX 4080 16GB and RTX 4080 12GB models hopefully next month. Yes, there are two almost completely different 4080 models coming—but for now, let's just talk theoretical specs.

The biggest and fastest of the new Ada Lovelace GPUs, AD102 increases raw core counts by 71 percent compared with the existing Ampere GA102. That alone should provide a huge jump in generational performance, but Nvidia has also tuned critical paths in the architecture to hit substantially higher clocks than previous generation architectures. All the graphics cards announced so far have reference clock speeds of 2.5GHz or more, and Nvidia has reached speeds of 2.85GHz and even 3.0GHz. Combine the two and you get a theoretical performance uplift of 130 percent.

Let that sink in for a moment. Assuming relatively similar architectures—and everything Nvidia has said so far indicates that most of the base functionality in Ada isn't radically different from Ampere—the fastest RTX 40-series card could double what we've seen from the RTX 3090 Ti. Or stepping down to the new RTX 4080 12GB, it still has 35 percent more theoretical performance than the existing RTX 3080 10GB, while using 11 percent less power. There will of course be custom cards from Nvidia's add-in board partners that come overclocked and use more power in pursuit of higher performance, but the baseline specs look very promising indeed.

CASHING IN ON CACHE

The memory subsystem is the one area that might hold Ada Lovelace back. Nvidia says it has worked with Micron, the exclusive manufacturer of GDDR6X memory, to move to a new process node and reduce the power consumption of the memory. Clocks are also increasing in some cases, but not by much. So far, the RTX 4080 16GB has been announced with 22.4 Gbps GDDR6X, while the 4090 and 4080 12GB both stick with 21 Gbps memory — the same as the RTX 3090 Ti. But the memory interface width either stays the same in the case of the 4090 versus 3090/3090 Ti and shrinks with the 4080 models.

The RTX 4090 has slightly more than double the compute resources as RTX 3090 Ti, but both cards have the same raw memory bandwidth. Normally speaking, bandwidth needs

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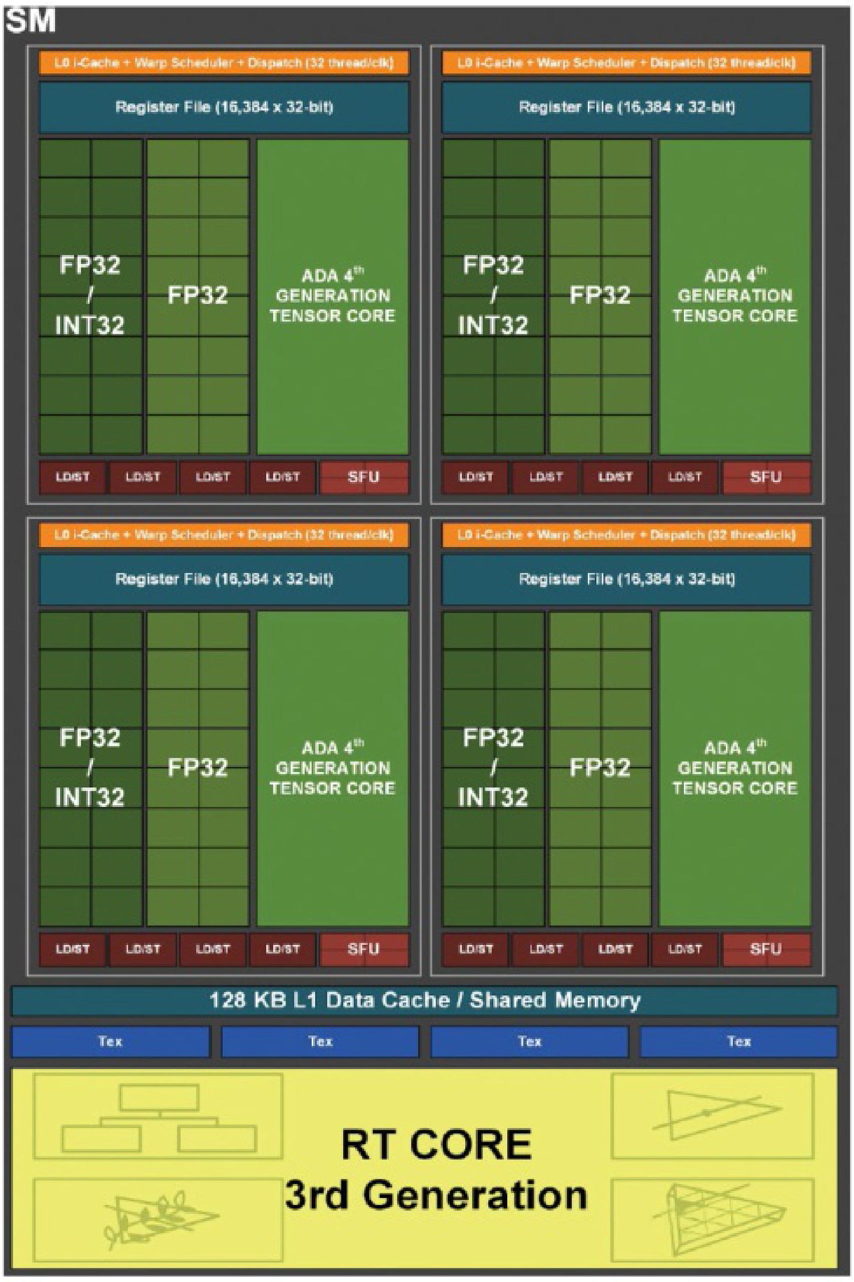

SM
L0 i-Cache + Warp Scheduler + Dispatch (32 thread/clk)
Register File (16,384 x 32-bit)
FP32 / INT32
FP32
ADA 4th GENERATION TENSOR CORE
LD/ST
SFU
128 KB L1 Data Cache / Shared Memory
Tex
RT CORE 3rd Generation

The Ada Streaming Multiprocessor packs third-generation RT cores and fourth-gen Tensor cores with enhanced GPU shaders.

SPEEDS AND FEEDS

On the right are the core specifications for the three announced Ada Lovelace GPUs, though the actual graphics card models may use harvested dies to improve yields.

The RTX 4090 uses AD102 with 128 SMs and 11 GPC clusters with a 2510MHz clock speed and 72MB of L2 cache enabled. RTX 4080 16GB uses AD103, with 76 of the available SMs enabled and a 2505MHz boost clock, while RTX 4080 12GB with AD104 uses the fully-enabled chip with a 2610MHz GPU clock.

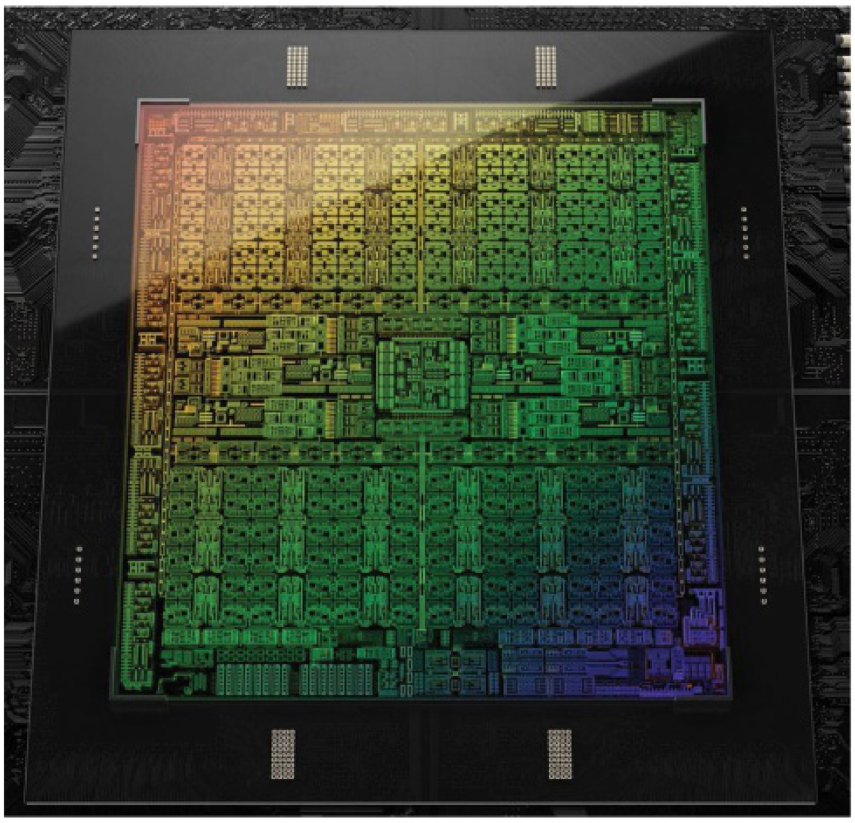
The amount of the chip that's enabled currently corresponds to die size, with the larger chips having fewer of the functional units turned on, presumably to improve yields. Power requirements are also a consideration. Nvidia has already successfully overclocked AD102 to more than 3.0 GHz. That probably required far more power than the RTX 4090's default 450W but it does potentially make the third-party card lineup more interesting.

We've set all three GPUs to the same core clocks and memory speeds for comparison purposes, using 2.5GHz and 21Gbps GDDR6X. That would give the AD104 nearly the same theoretical FP32 compute performance as the existing RTX 3090 Ti, thanks to the significantly higher boost clock (3090 Ti runs at 1850MHz). AD103 has 33 percent more SMs, cores, cache, memory, and bandwidth. AD102 delivers a sizeable 80 percent increase in cores over AD103, with 50 percent more memory, bandwidth, and cache.

The memory bandwidth figures are one of the big potential sticking points, but as AMD aptly demonstrated with its RDNA 2 architecture and the RX 6000-series graphics cards, a bigger chunk of cache can do wonders for effective bandwidth. Assuming Nvidia gets similar results, and we don't see why not, effective bandwidth could be double that of the RTX 30-series, even though raw bandwidth hasn't really changed.

to scale up with the compute for a GPU to deliver improved performance, but trying to strap a 768-bit interface onto Lovelace would have been prohibitively expensive. So, just like AMD did with RDNA 2, Nvidia has massively increased the GPU cache to improve the effective bandwidth.

The L2 cache in Ada is up to 16 times larger than Ampere's L2 cache—up to 96MB for AD102, compared with just 6MB for GA102. The L2 cache performance will also benefit from the substantially higher core clocks. However, higher resolutions still give us some cause for concern. AMD's RDNA 2 GPUs had up to 128MB of Infinity Cache, and its published cache hit rates ranged from as high as 80 percent at 1080p to just 55 percent at 4K. That would still roughly double the effective bandwidth of the RTX 4090, but the RTX 4080 16GB by comparison might only have 43 percent more effective bandwidth compared to the previous-generation RTX 3080 Ti.



Nvidia's AD102 die, in all its glory, with up to 18,432 CUDA cores clocking in the 2.5 GHz range; it may deliver the biggest jump in performance that we've seen from Nvidia.

ADA'S ARCHITECTURAL ADVANCES

It's not just higher clock speeds and more cores, naturally. As with every new GPU architecture, Nvidia has taken some time to improve the various functional units—the GPU cores (shaders), RT cores, and Tensor cores. In a lot of ways, the RTX 40-series launch seems to echo the RTX 20-series launch, because the two biggest talking points are the same things we heard about back then: ray tracing and DLSS. Let's start with the updates to the GPU and RT cores first.

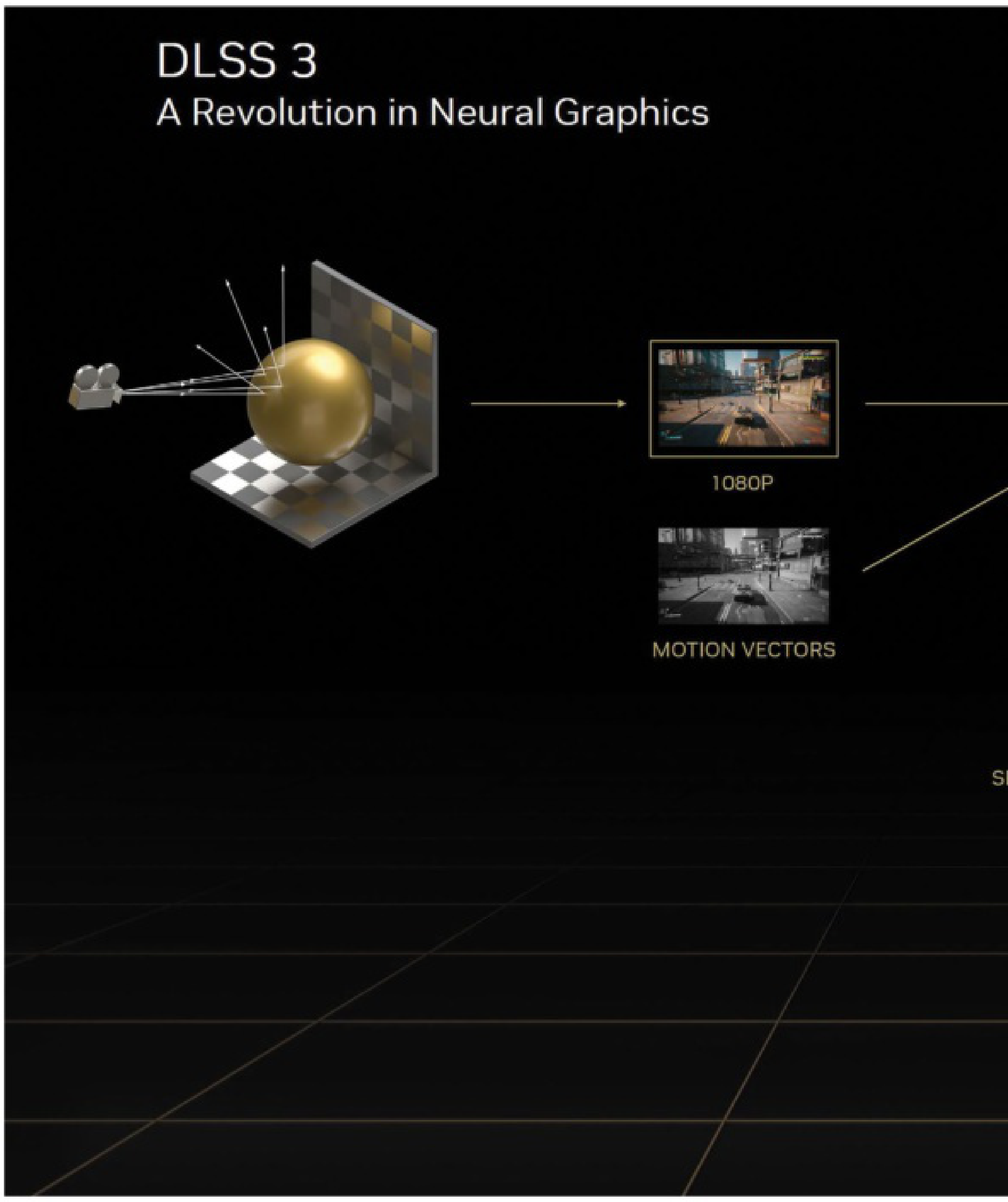
ADA LOVELACE GPUS

	AD102	AD103	AD104
Transistors (Billion)	76.3	45.9	35.8
Die size (mm^2)	608.4	378.6	294.5
GPCs	12	7	5
SMs	144	80	60
GPU Shaders	18,432	10,240	7,680
Tensor Cores	576	320	240
RT Cores	144	80	60
ROPs	192	112	80
TMUs	576	320	240
VRAM (GB)	24	16	12
VRAM Bus Width	384	256	192
L2 / Infinity Cache	96	64	48
TFLOPS FP32	92.2	51.2	38.4
TFLOPS FP16 (FP8)	737 (1,475)	410 (819)	307 (614)
Bandwidth (GBps)	1008	672	504

RTX 40-SERIES GRAPHICS CARDS

	RTX 4090	RTX 4080 16GB	RTX 4080 12GB
Architecture	AD102	AD103	AD104
SMs	128	76	60
GPU Shaders	16,384	9,728	7,680
Boost Clock (MHz)	2,520	2,505	2,610
VRAM Speed (Gbps)	21	22.4	21
VRAM (GB)	24	16	12
VRAM Bus Width	384	256	192
L2 / Cache	72	64	48
ROPs	176	112	80
TFLOPS FP32 (Boost)	82.6	48.7	40.1
TFLOPS FP16 (FP8)	661 (1,321)	390 (780)	321 (641)
Bandwidth (GBps)	1,008	717	504
TBP (watts)	450	320	285
Launch Price	$1,599	$1,199	$899

Specifications for the fully enabled Ada Lovelace GPUs (left) along with the announced retail RTX 40-series parts using those GPUs (right), all built on TSMC's 4N (4nm Nvidia) process node.



DLSS 3

A Revolution in Neural Graphics

Nvidia has added a new feature to the GPU cores called Shader Execution Reordering (SER). Nvidia claims that SER for shaders is as big an advance as out-of-order execution was for CPUs, with potentially large gains in efficiency in throughput. One problem with shader execution is that the SMs (Streaming Multiprocessors) work best when they're running the same code on all the shader pipelines. That applies to AMD's Compute Units (CUs) and Intel's Xe cores too, incidentally. All three of the major GPU companies now have 128 shader pipelines grouped together, and, ideally, you want them to finish their work at the same time.

Without SER, it's basically luck of the draw to a certain extent. Pixels that come from the same polygon will likely end up running the same shaders, but there will inevitably be a mix due to workloads not matching up perfectly with the available execution resources. SER allows the GPU to reorder things to better fill the pipeline slots. Nvidia claims performance improved by 20 to 44 percent in several test cases, with an average improvement of around 25 percent. There's a catch, however—SER isn't something that automatically happens. Developers need to tag shaders to inform the GPU on how to best group them, which means SER only works on games that explicitly support it. Nvidia also notes that SER helps most in ray-tracing workloads, where adjacent pixels on a polygon might end up with completely different shaders due to reflections.

While SER might help non-ray tracing workloads as well, the next two architectural enhancements are specific to the RT cores. Displaced Micro-Meshes (DMM) help to dramatically simplify the generation of the BVH (Bounding Volume Hierarchy) structure. BVH is designed to help optimize ray-tracing calculations so that having ten times as many triangles in a scene might only

© NVIDIA

A ROSE BY ANY OTHER NAME

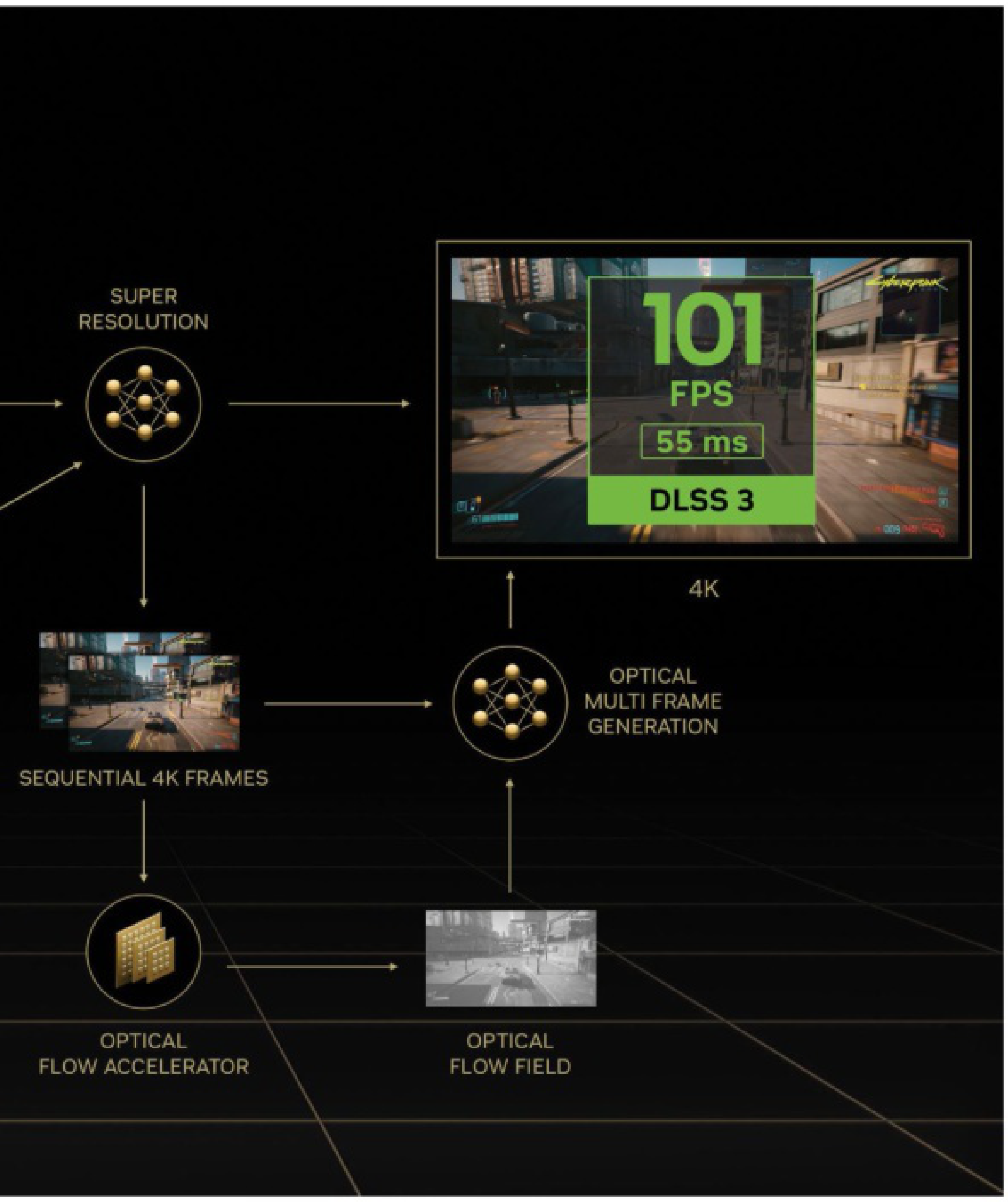
Nvidia's model naming conventions don't always make sense, and that's especially true of the RTX 4080 12GB. Last generation, Nvidia revealed the RTX 3090, 3080, and 3070 at the same time. The previous generation Turing reveal consisted of the RTX 2080 Ti, 2080, and 2070. This time, we have RTX 4090, 4080 16GB, and 4080 12GB. Let's also point out that the 30-series launch consisted of three cards using two different GPUs (GA102 and GA104), while the Turing and Ada announcements have three cards using three GPUs. What's going on?

Shakespeare's Juliet opined that roses smell just as sweet, regardless of their name, and we can extend that to graphics cards as well: An AD104 GPU will run just as fast, whether we call it an RTX 4080 12GB or an RTX 4070. But the problem isn't just the name, it's the pricing. There's been a build-up in the RTX 30-series card inventory and used mining cards are expected to flood the market. Nvidia wants to help clear out those cards, and it's bumped up the launch pricing on the RTX 40-series cards by $100 to $200 compared to the 30-series.

We've seen the 70-class GPUs go from $329 with the 970 up to a high of $599 with the 2070, then back to $499 with the 3070. Clearly, Nvidia doesn't want a new RTX 4070 priced at $499 or even $599 that could compete with existing RTX 3090 and 3080 Ti cards. The solution? Just call it the RTX 4080 12GB. To say that gamers are not happy would be an understatement, but just imagine how mad people would be if Nvidia was trying to sell an RTX 4070 for $899!

Still, it's painful to see. Current generation cards have finally started to sell for close to their respective MSRPs, after cryptocurrency mining, the pandemic, and supply chain issues all played their role (see *Tech Talk*, page 11). We'll probably need to wait until 2023 for an RTX 4070, using a harvested AD104 chip, to get a more affordable Ada card.

Nvidia will have a Founders Edition of the 4080 16GB but not the 4080 12GB. Shouldn't these just be called the RTX 4080 and RTX 4070?



Enhancements to the Tensor cores allow for much improved DLSS performance, and DLSS 3 'requires' the improved Optical Flow Accelerator.

double the ray-tracing time. The problem is that the initial BVH generation, which is typically done on the CPU, increases linearly with size. A single BVH might be used for lots of ray-tracing calculations, but there's a better way to reduce the complexity. Using displacement maps like those used with tessellation techniques, a simple polygon can represent far more complex geometry. The third-gen RT cores have been designed to work in this way, and Nvidia says the resulting BVH generation is typically ten times faster and requires 1/20th of the storage space, and overall RT performance also improves.

Opacity Micro-Masks (OMM), on the other hand, specifically work to accelerate RT workloads that involve partially transparent surfaces—leaves, fences, particles, and that sort of thing. Without OMM, every ray that encounters a transparent texture ends up bouncing back to the shaders to determine if it is an opaque or transparent part of a texture. With OMM, the RT cores can determine whether a ray has hit a transparent pixel, an opaque pixel, or 'unknown'—pixels that are partially blocked and therefore could go either way.

With the first two cases, the RT core can directly determine the next step, so it's only the unknown cases that need to go back to the shaders for further calculations. Depending on the scene, OMM can improve performance by 10 percent or more. As with SER, however, both DMM and OMM are new features that aren't yet part of the core DirectX 12 or Vulkan RT APIs. They are accessible via NVAPI extensions, and Nvidia says it's working

GET READY FOR DLSS 3

A big talking point from Nvidia since the first RTX cards back in 2018, DLSS is perhaps the biggest potential change with Ada Lovelace.

Using deep learning and artificial intelligence networks, DLSS attempts to intelligently upscale a lower-resolution source frame into a higher-resolution result. While the basic idea sounds relatively straightforward, in practice there has been a lot of trial and error.

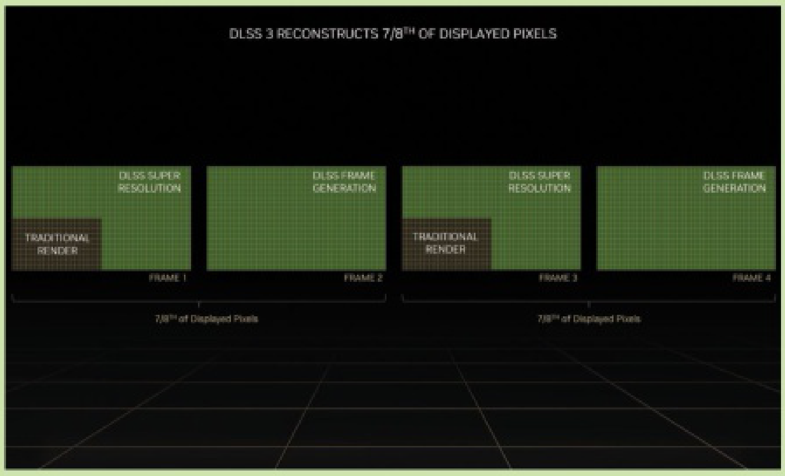
DLSS 1 used spatial upscaling, required per-game training, and only worked with certain upscaling factors depending on your GPU. Worse yet, it didn't even look that great. Nvidia has been beating the 'better than native' drum since the beginning, but back in 2018, that was a laughable claim.

DLSS 2 fundamentally changed the approach, shifting to a universal network (no per-game training) combined with temporal upscaling using multiple frames of data, the depth buffer, and motion vectors. With more input data coupled with better AI models, the resulting output quality improved tremendously.

Now, DLSS 3 looks to kick things into overdrive. The Super Resolution upscaling algorithm from DLSS 2 is still part of the package, and on pre-40-series RTX GPUs that's all you'll get (for now). But Ada includes a dramatically improved Optical Flow Accelerator (both Turing and Ampere had OFAs, just not as fast or capable) that's designed to take all the existing inputs into the upscaling algorithm, and then generate a second frame of output.

How does it look and feel? We're still waiting for our first hands-on experience with DLSS 3, but it certainly sounds cool. We worried about increased latency at the cost of framerate, but DLSS 3 requires Nvidia Reflex as well, which apparently balances out the overall experience.

Potentially doubling performance, even in CPU bottlenecked situations, would be great, though note that input responsiveness would still be tied to rendered frames. Hopefully, the results will live up to Nvidia's claims, and maybe previous-generation Ampere might eventually benefit as well.



Frame Generation provides a two-for-one special. The Performance mode upscales 1080p to 4K, then creates a second frame via AI magic, so only 1/8th of the pixels sent to your screen need to be rendered.

LEAVING ROOM FOR RTX 4090 Ti

Looking at the announced graphics cards, there are plenty of holes to plug. For instance, there's a rather huge gap between the RTX 4090 and the RTX 4080 16GB, which could easily be filled with an RTX 4080 Ti when it's time for the inevitable refresh.

Obviously, we're missing anything below the RTX 4080 12GB for now, and we expect Nvidia will launch plenty of other 40-series cards over the coming year. But there's also room for something faster at the top of the pecking order.

RTX 4090 only has 89 percent of AD102's GPU, Tensor, and RT cores enabled. It's also missing out on 24MB of the maximum 96MB of L2 cache, and one of the GPC clusters is disabled, taking one of the ROPs clusters with it. This was almost certainly all done to improve yields for the first AD102 parts, though Nvidia also has fully enabled AD102 GPUs getting ready to ship in its professional RTX 6000 cards with 48GB of memory.

But that's not all we're missing. Earlier this year, Micron made an announcement that it was preparing 24Gbps GDDR6X memory. So far, the fastest GDDR6X will be in the RTX 4080 16GB, clocked at 22.4Gbps. We also heard plenty of rumors that Nvidia was toying with a 600W TBP (Total Board Power) for the top RTX 40-series parts, which obviously isn't happening with the RTX 4090 Founders Edition, but with Nvidia's talk of 3.0 GHz overclocks we can't help but wonder.

Pair a fully enabled AD102 clocked at perhaps 2.8GHz with 24Gbps GDDR6X and a 600W power limit and the theoretical performance would improve by around 25 percent over the RTX 4090, with 14 percent more memory bandwidth. That kind of extra power would allow the card to make use of the clock speed headroom as well.

Put it all together and we could be looking at the future RTX 4090 Ti! Nvidia, make it so.

As potent as the RTX 4090 looks, Nvidia has definitely left some room for a future higher-performance RTX 4090 Ti.

to get these techniques adopted by the main APIs, but until that happens, we expect they will see limited use, just like ray tracing.

Speaking of which, Nvidia will double the ray/triangle intersection units with Lovelace, doubling the RT cores' performance in general ray-tracing workloads. Unlike the other enhancements, this will be transparent to developers—the RT hardware will simply be faster, up to double the per-core performance. This will enable game developers to potentially use more ray tracing in their games. As an example, Nvidia says that *Battlefield V* averaged around 39 RT operations per pixel, while the latest updates to *Cyberpunk 2077* with RT Overdrive mode enabled—a new option created just for the RTX 40-series launch—will average 635 RT operations per pixel. That's a 16-times increase in ray tracing calculations in just four years.

TENSOR CORES AND THE OFA

The Tensor cores also have some new functionality, and there's a little-mentioned piece of fixed-function hardware called the Optical Flow Accelerator (OFA) that we need to discuss. Both play a key role in DLSS 3 (see sidebar), which has the potential to double framerates compared with DLSS 2.

The fourth-gen Tensor cores are functionally a bit of a cross between Ampere's Tensor units and Hopper H100 (see the *Tech Talk* column, May 2022 issue), Nvidia's supercomputer and data center AI powerhouse GPU. The biggest update is that they

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AMD CEO Lisa Su teased that it has working RDNA 3 during the Zen 4 CPU announcement, and we'll get more details next month.

© AMD

now support FP8 (8-bit floating-point) calculations and the FP8 transformer engine. As the name implies, FP8 uses half the bits of FP16, and potential compute performance gets doubled. Hopper Tensor cores have additional functionality such as FP64 support and offer twice the per-clock compute performance of Lovelace, but due to the FP8 support, they are both referred to as fourth-generation Tensor cores.

We're told DLSS fully supports running all its calculations in FP8 mode, which means the potential compute with sparsity now tips the scales at a whopping 1.32 petaflops on the RTX 4090. In comparison, the RTX 3090 Ti maxed out at a meager 320 teraflops. That's a huge four-times gulf in performance now, which gives Nvidia more options for enhancing the quality of the upscaling, and means DLSS could provide upscaled results faster than on previous-generation GPUs. But Tensor cores aren't the only DLSS-related tech to get an upgrade.

Both Turing and Ampere GPUs have an Optical Flow Accelerator (OFA), which has been present since the Turing generation but wasn't previously used with DLSS. Typical uses for OFA previously included reducing latency in augmented and virtual reality, improving the smoothness of video playback, enhancing video compression efficiency, and enabling video camera stabilization. It was also used with automotive and robotic navigation, and video analysis and understanding.

The Ampere generation upgraded the OFA to a 126 teraops (INT8) fixed function unit, and now Ada boosts the OFA up to 305 teraops. The added performance and other enhancements now

TEAM RED'S RDNA 3

Nvidia isn't the only GPU game in town. AMD is hard at work on its Radeon RX 7000-series cards and RDNA 3 GPUs. We should have more details next month, but we already know what to expect.

Current indications are that AMD will be providing a similarly huge jump in GPU core counts compared to RDNA 2, just like AD102 over GA102. The current Navi 21 GPU tops out at 80 Compute Units (CUs), 128MB of Infinity Cache, and a 256-bit memory interface paired with vanilla GDDR6 memory. Navi 31 will reportedly have 96 CUs, but each CU will have twice as many shader units as RDNA 2. That means a maximum of 12,288 GPU cores.

While that's less than AD102's potential 18,432, keep in mind that the RX 6950 XT only has 5,120 cores going up against the RTX 3090 Ti's 10,752 cores, and yet AMD comes out ahead in traditional rasterization performance at 1080p and 1440p.

We anticipate some architectural enhancements with RDNA 3 as well, especially in ray tracing. Maybe that won't happen, as AMD seems far less enamored with RT than Nvidia, but the current RDNA 2 approach is lackluster. RDNA 2 uses shared resources with the texture units to perform BVH traversal at a rate of four ray/box intersections per cycle, which hurts AMD's RT performance. Nvidia has doubled the ray/triangle throughput on its RT cores again, and we hope AMD will do the same, plus providing dedicated BVH traversal hardware.

But the biggest change with RDNA 3 will be AMD's move to a chiplet architecture. Chiplets made AMD far more competitive with Intel in the CPU realm, with Zen 3 taking the lead for about a year. Navi 31 will reportedly consist of one large GPU chiplet that houses all the CUs, ROPs, and other typical hardware, and it will link with up to six memory chiplets each with a 64-bit GDDR6 interface and 16MB of stacked Infinity Cache—possibly 32MB of cache on the highest end models. The die size for the main GPU chiplet will be about half as large as AD102, reducing AMD's costs.

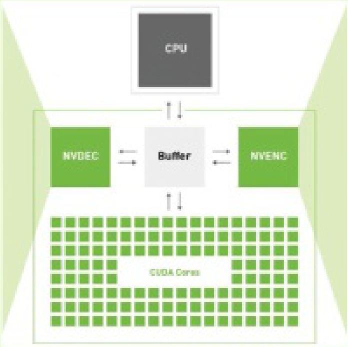
The memory chiplets will be manufactured on a previous generation node, which won't matter too much as cache and analog interfaces are the two things that scale worst with die shrinks.

We could also point to Intel's Arc GPUs, which are finally out (see Arc A770 on page 78), but clearly, Intel isn't going to touch Nvidia Ada or AMD RDNA 3 on raw performance with Arc Alchemist. But perhaps Battlemage will close the gap next year.

Intel's Arc GPU's are finally out — see our Arc A770 review on page 78

intel ARC
intel ARC

DUAL AV1 ENCODING



Lovelace GPUs with 12GB or more VRAM will feature two NVENC units, upgraded with AV1 support.

One of Intel's claims to fame with the Arc GPUs is that they support AV1 encoding, something none of the other graphics cards have supported. With Ada Lovelace, one of Intel's few selling points gets some competition, though, of course, the current entry price for the RTX 40-series remains substantially higher than Arc A380.

Nvidia isn't just adding AV1 support, however. The RTX 4080 12GB and above—perhaps even a future RTX 4070—will all have two NVENC blocks. These can either work on separate streams or combine to double encoding rates. Nvidia has been working with Black Magic on DaVinci Resolve, the Voukoder plugin for Adobe Premiere Pro, and Jianying (the top Chinese video editing app) to include support for the updated NVENC unit.

AV1 allows for a 40 percent reduction in bitrates compared to H.264, at the same file size. With Intel and Nvidia now supporting AV1 encoding in hardware—AMD has said RDNA 3 will have AV1 support too—streaming and video applications are set to get a sizeable boost to quality and performance in the coming months.

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Nvidia's hardware may now be at the point where developers can let their creativity run wild without worrying about how it runs.

allow it to be used to create the optical flow field that's part of DLSS 3 frame generation. While the higher performance and capabilities of the Ada OFA are currently required for DLSS 3, there's a bit of wiggle room. Nvidia's Bryan Catanzaro, VP of Applied Deep Learning Research, tweeted that it was "theoretically possible" for DLSS 3 to eventually work on Ampere GPUs. However, it would likely run at lower quality and performance levels, and may never actually happen.

MISSING THE CUT

With all the things that Ada Lovelace does include, it's also important to point out some of the items that didn't make the cut. Most of these were left out either because Nvidia didn't feel they were necessary, or because the potential gains weren't worth the additional die space.

First, the interface on Ada remains PCIe 4.0, not 5.0. Hopper supports PCIe 5.0, but Nvidia claims that there's little need for a faster, more complex, and more power-hungry PCIe interface on its consumer GPUs.

Next, in a rather surprising move, Ada won't support DisplayPort 2.0. The standard has been ratified for use since 2019, so we were somewhat surprised it wasn't in Ampere, but three years later and still no DisplayPort 2.0? That's shocking, as even Intel Arc supports the standard. DP 2.0 would add support for 4K at up to 240Hz, and 8K at 60Hz, without any need for Display Stream Compression. DisplayPort 1.4a has been around for a long time, and it can do 4K 144Hz, but only with DSC. HDMI 2.1 is still present, which can also do 8K 60Hz, but again only with DSC.

Finally, there's no NVLink connector on any of the Ada GPUs. Again, this eliminated some die area that was used elsewhere, but this effectively puts the lid on the SLI coffin, nails it shut, and then buries it six feet under. Applications could still explicitly support multi-GPU, but almost no new games have bothered with SLI for the past couple of years, and with Nvidia apparently not willing to support the endeavor, we can only reminisce about the good old days of microstutter and added latency and move on.

GEFORCE RTX
SUPRIM

The NVLink connector on the RTX 3090 Ti no longer exists with Ada GPUs like the RTX 4090, effectively killing off dual-GPU gaming. RIP, SLI.

RTX ROUND 3: MORE RAY TRACING, MORE DLSS

Lovelace represents a huge upgrade over the previous Nvidia Ampere architecture. To say we're excited to move on from the past two years of scarcity, crypto mining, and extreme GPU prices would be an understatement. We've seen big generational improvement from Nvidia before, and we don't want to count our chickens just yet, but Ada might just be the largest single jump in performance that we've seen from GPUs since Nvidia coined the term back in 1999. Certainly, the specifications and architectural upgrades look like a bigger jump than we saw with the Ampere, Turing, Pascal, and Maxwell generations—though Kepler delivered a similar jump relative to Fermi about a decade ago.

At the same time, the RTX 40-series feels reminiscent of the RTX 20-series launch. Nvidia has focused once again on ray tracing and DLSS as major areas of improvement. We don't doubt that games that make heavy use of RT effects and then leverage DLSS 3 will run far better on Ada GPUs than on anything else. The question is whether we'll see enough of such games to warrant the upgrade. *Portal RTX* looks very enticing, *Cyberpunk 2077* with RT Overdrive less so. Nvidia also has a new tool called RTX Remix that modders can use to potentially convert old games into new and improved 'mods' that have full ray-tracing support and AI-upscaled textures. It showed some cool demonstrations using *The Elder Scrolls III: Morrowind*, and we could be looking at a reinvigorated modding community if it catches on.

The gains in traditional gaming performance are not as large, however, and you can read our RTX 4090 review for more info on that. For every *Racer RTX* or *Portal RTX*, there are dozens of games that don't use ray tracing at all, plus a great number of gamers still aren't using a 4K monitor to take advantage of it. With the third generation of RTX graphics cards, however, Nvidia's hardware may finally be at the point where artists and game developers can let their creativity run wild and stop worrying so much about how it runs. Nvidia has built Ada Lovelace; let's see if games that fully use it will come in sufficient quantities.

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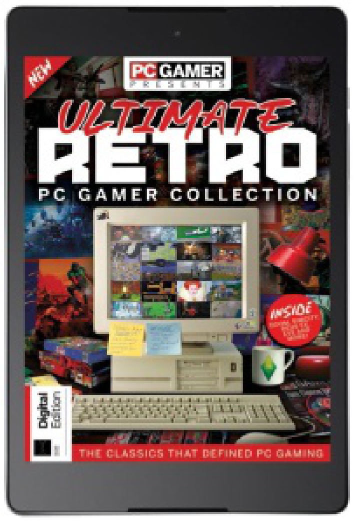
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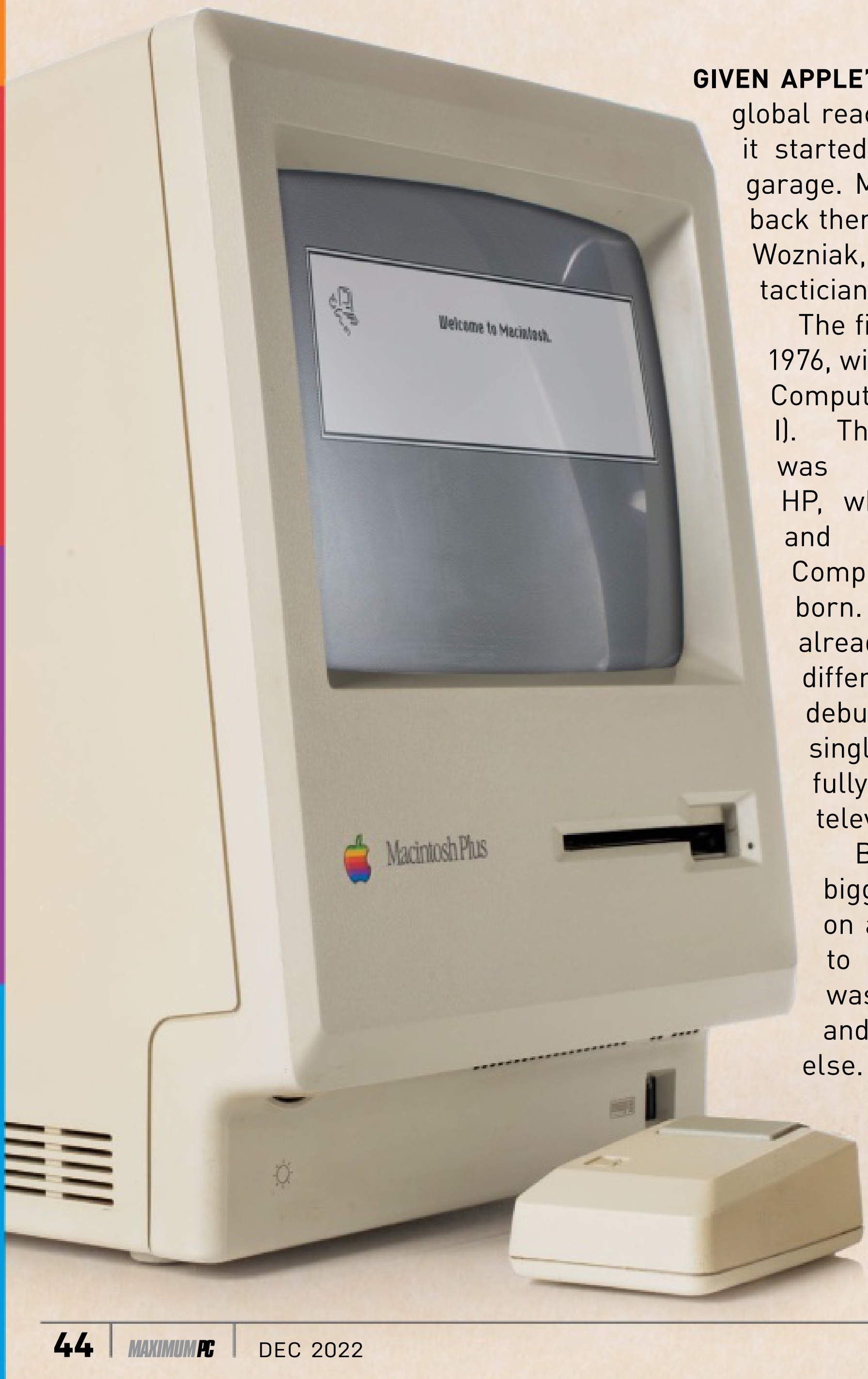
History of Apple

With Apple now in its fourth decade, ***Craig Grannell*** explores some of the key products from its history, the impact they had on gaming, and the sometimes surprising impact that gaming had on Apple itself



GIVEN APPLE'S gargantuan profits and global reach, it's easy to forget that it started life as two people in a garage. Much of the tech wizardry back then was down to Steve 'Woz' Wozniak, while Steve Jobs was the tactician and visionary.

The first breakthrough came in 1976, with what became the Apple Computer 1 (later known as Apple I). The machine was offered to HP, who declined, and so Apple Computer was born. Apple was already 'thinking different', its debut hardware being the first single-board computer, sold fully assembled and using a television for output.

Mac OS
Starting up...

But Woz was thinking even bigger. Inspired by his work on arcade games, he wanted to create a computer that was faster, more colorful, and noisier than anything else. Ultimately, as he recalled in a 1986 interview with *Call-A.P.P.L.E.*: "A lot of the features of the Apple II went in because I had designed *Breakout* for Atari. I had designed it in hardware. I wanted to write it in software now."

With Apple rarely being equated with gaming, it's surprising to discover its foundations rest on one man's desire to program a BASIC version of *Breakout*. But soon Woz was tinkering with his computer, adding color, BASIC commands, paddle controllers, and sound. Building primarily for himself, he also kickstarted a computing revolution—the Apple II captured the imagination of wannabe home programmers, and the machine's initial success bankrolled Apple for years.

Prior to founding EA, Trip Hawkins was director of strategy and marketing at Apple Computer, and recalls the Apple II fondly. "It was so far ahead of its time that photographers setting up images of the future would include an Apple II in the shot," he says. *Ultima* creator Richard Garriott was similarly impressed. He'd battled with teletype terminals, but then found himself sat before an Apple II.

"I was in wonder. Suddenly, instead of invoking a command and waiting minutes for it to process and print the results, I had a computer that in real time could visually display to me any fantasy worlds

© APPLE CORP

and other fantastical ideas I could think about. I immediately saw it as the key to the future—or my own future, at least!"

There were, naturally, drawbacks. Woz's products had their quirks, and the Apple II needed someone to make the most of it. "You had to be a great assembly language programmer and that kind of person is often not a great designer or artist," says Trip. "Brilliant talents like Bill Budge could envision bigger ideas and be able to execute them in an interdisciplinary fashion, as he did with the revolutionary *Pinball Construction Set*."

However, many programmers found much of the pleasure in using an Apple II arrived from working out how to coax tiny gaming universes out of the machine. "It was the first computer with decent graphics yet also simple enough that you could hold a model of the entire machine in your head," explains *Wizardry* creator Robert Woodhead. "Programmers knew everything about the platform, and part of the fun was figuring out ways to get the machine to do stuff. One example was Woz's hack of using software to do all the expensive stuff needed to run a floppy disk

> I remember being disappointed at how few games were made for the Mac *Christopher Gross*

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Target: Solthi
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WEAPON DISPLAY
Weapon: Javelin HS
Gun: Neutron gun
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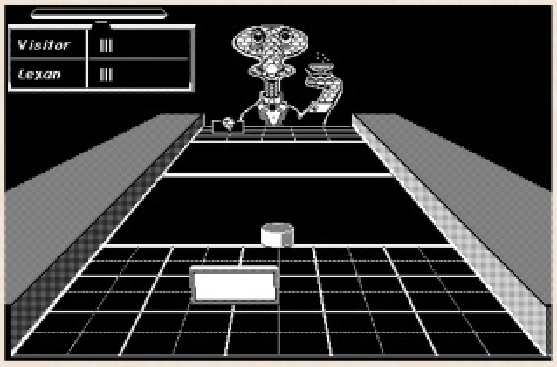


***Shufflepuck Cafe* was a killer app for the early Macs.**

controller, making the hardware simple and cheap, and then his 're-hack' that increased disk capacity via code changes."

At the time, no one felt constrained by the perceived limitations. *Bard's Tale* creator Michael Cranford says that "having a fixed, limited canvas can be an inspiration to something better". He says that with today's hardware, the lack of limits makes it tough to push hardware and inspire people. Similarly, John Romero enjoyed the Apple II's 'limitations', which dictated what you could create. This gave games on the system a certain character, using individual techniques that could "literally provide you with unique identification of a programmer," he says.

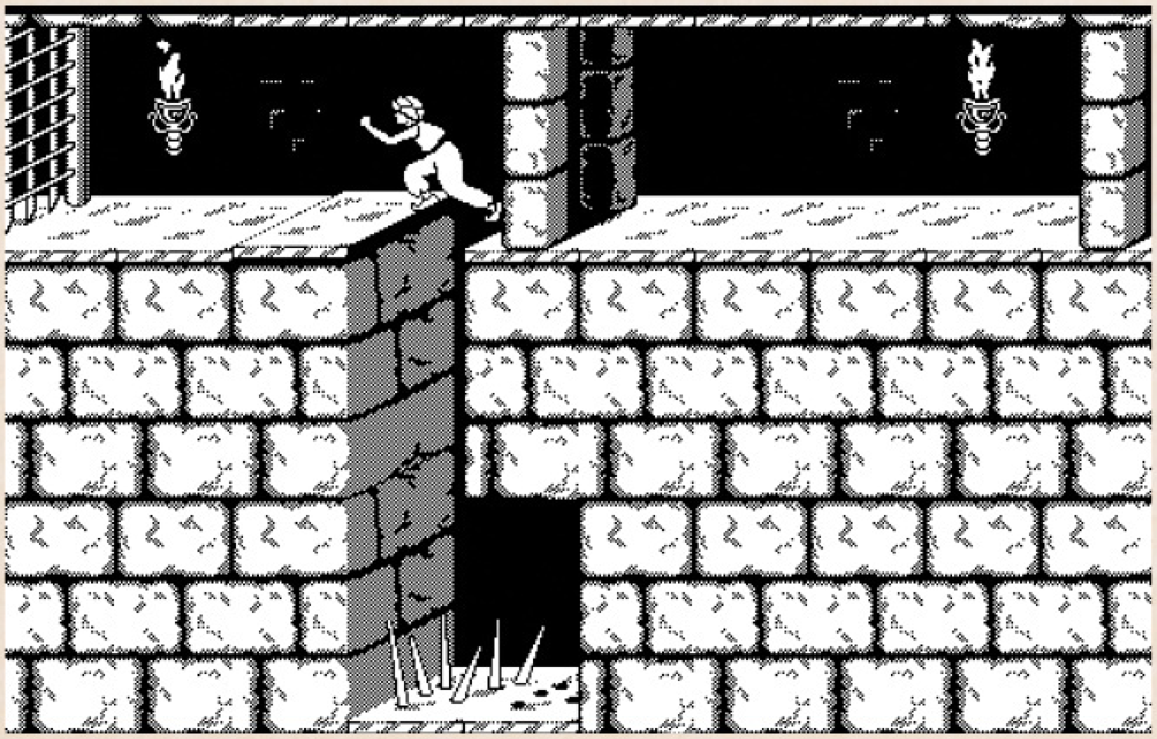
The hardware continued to evolve, but internal politics eventually derailed the Apple II. An attempt at a business-focused follow-up, the Apple III, was a failure. And although the Apple II line eventually transformed into the next-generation Apple IIGS, it lacked a champion and was superseded by the Macintosh. Even so, that didn't stop people from wanting to create games for the Apple II in its twilight years. Having used his Apple II to create *Karateka*, Jordan Mechner unveiled *Prince Of Persia* on what was considered a dying platform. His reasoning? "The Apple II was a platform I understood. It was a lovely machine."

The early days of the Macintosh were fraught with problems. Even today it's hard to get a handle on precisely what occurred, on account of the people involved having different recollections. The basic facts are that the project was started by interface expert Jef Raskin, who wanted to create a consumer-oriented low-cost computer named after his favorite apple, the McIntosh. Over time, the scope of the Mac shifted, Steve Jobs jumped on board from the beleaguered Apple Lisa project, causing Raskin to quit, and the boxy little Mac finally said 'hello' in 1984.

Although the Mac was different from Raskin's concept, aspects of his vision remained intact. Inspired by technology developed at Xerox PARC and also in-house at Apple, the Mac boasted a revolutionary visually-oriented operating system, based around a now-familiar desktop with windows and folders. The all-in-one main unit had a small 512x342 pixel display. And the only things you needed to plug in were a power cord, keyboard, and mouse.

Much like the Apple II before it, the Mac offered a bold take on the future of computing, and people couldn't help but be seduced. "It struck me as a qualitative shift," says Christopher Gross, who designed air hockey titles *Shufflepuck* and *Shufflepuck Cafe* for the system. "The graphical interface and mouse allowed a shift from 'asking the computer to do something' to just being able to do it." In other words, this was a computer designed to enable users to perform actions directly, rather than type commands and hope for a correct interpretation. Gross was so taken aback that he quit a computer science grad program, because "programming for the Mac was so much more interesting and real than anything I was doing in school".

The Mac soon found a niche but it wasn't games. "Macs became mostly used for desktop publishing and artwork. They became typecast," says Romero. In wanting to stop its computer from failing, Apple did little to dispel this notion, reasoning that any focus on games might find its hardware written off as a toy. Gross says that those who did start working on Mac games rarely tried to innovate with the controls available to them. "Having a mouse by default didn't really shake things up," he says. "I remember being disappointed at how few games were made for the Mac, but also how few used the mouse beyond the obvious ease of being able to directly point at things on



Released in 1989, *Prince Of Persia* had stunning animation for the time. A color version was eventually released on later Macintoshes.

Apple Timeline

1 APRIL1976
The now-corporate giant that is Apple is founded in Los Altos, California, by Steve Jobs, Steve Wozniak, and Ronald Wayne.

11 APRIL 1976
Apple Computer 1 (later known as the Apple I) is released, with each unit being hand-built by Steve Wozniak.

10 JUNE 1977
The Apple II is launched, and its success bankrolls Apple for a decade, giving the company breathing space.

19 MAY 1980
The Apple III hits the market and fares poorly, not least due to issues with Apple II compatibility. It was reintroduced in 1981.

19 JANUARY 1983
The Apple Lisa launches. The UI was revolutionary, but the computer was sluggish and the sales were poor.

22 JANUARY 1984
The Ridley Scott-directed Apple ad plays at Super Bowl XVIII in 1984 and is hailed as one of the best adverts ever.

the screen." In part, this was what drove Gross to use the mouse as a controller in *Shufflepuck*. The game was also 'blessed' with the happy accident of 'weight' being afforded to the puck through a time delay in the graphics that occurred whenever a sound played as the puck was hit!

Bill Dugan, then a producer at Interplay, also recalls issues with Apple's lack of interest and the system's reliance on the mouse. "Computer games were developed on a lead platform, released immediately, and ported to whatever other platforms would sell," he says. "The Apple II or C64 was usually the lead platform in the USA, then you'd see ports to the PC, Mac, and other systems. Publishers wanted ports to be fast and cheap."

For some platforms, a low-cost approach worked well, but this was less so for more powerful platforms, due to the expectations of those who owned them. And with the Mac, the default interaction was pointing and clicking, not keyboard commands. Direct game ports to Mac had a tendency to feel alien, lacking a mouse interface, or having a 'fake' one awkwardly welded on. "Essentially, you'd click on keyboard command equivalents. In the lower levels of the code, the programmer could then pretend there was no mouse at all, and use the same interface code that had been written for a non-mouse original," explains Dugan.

The display was a brighter spot. Gross notes that it was high-res, which "allowed a relatively high mouse resolution". Dugan says its monochrome nature forced anyone porting games to take care. "The Mac's black-and-white monitors made it unconscionable to copy and paste graphics from another platform. You'd have ended up with an awful, lumpy mess of unacceptable grey. So pretty much everyone recreated graphics for the Mac." Having noted all these things, and with the Mac press howling at terrible ports, Interplay hit upon the idea of making an effort on presentation, UI, and graphics, thereby making games more attractive

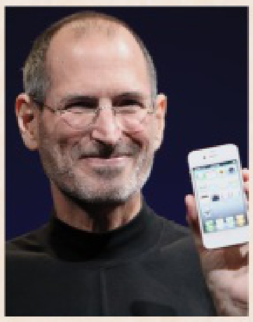
© PHOTO OF SUSAN KARE © R. J. MUNA, PHOTO OF STEVE JOBS © MATTHEW YOHE

Key players

The people who shaped Apple

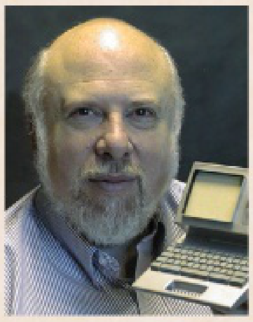
STEVE 'WOZ' WOZNIAK
CO-FOUNDER, ENGINEER

An amazing engineer, Steve 'Woz' Wozniak was the brains behind the Apple I and Apple II computers. Although still technically an Apple employee, Woz has had little to do with Apple since the mid-1980s.



STEVE JOBS
CO-FOUNDER, CEO

Steve Jobs saw the potential in Wozniak's work and became Apple's vision and taste arbiter. Ousted in 1985, he went on to found NeXT, but then triumphantly returned to Apple as CEO in 1997, reinvigorating the then-flailing company.



JEF RASKIN
INTERFACE EXPERT

Although many people were responsible for the original Mac, Jef Raskin instigated the entire project. Noting that computers at the time were aimed solely at geeks, he aimed to create something that was much more usable and friendly.

SUSAN KARE
GRAPHIC DESIGNER

The graphic designer on the original Mac computer line, Susan Kare created the icons, typeface, and interface conventions that permeated throughout the entire tech industry and that are still in use today.

JONATHAN 'JONY' IVE
DESIGNER, CHIEF DESIGN OFFICER

An Apple employee since 1992, British-born Jony Ive flourished after Steve Jobs returned. Chief designer of the iMac, iPod, and iPhone, among others, Ive's creations have influenced the entire tech industry.

24 JANUARY 1984
The first Mac arrives, providing the foundation for all of Apple's subsequent personal computing endeavors.

17 SEPT 1985
Steve Jobs resigns from the company and starts work on a new venture, NeXT. He returns to Apple in 1997 as CEO.

15 SEPT 1986
The Apple II hits its zenith with the IIGS, which blends the Apple II and Mac experiences and uses a color GUI.

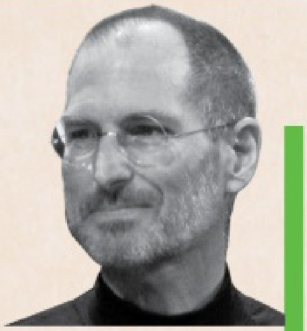
2 MARCH 1987
The Macintosh II arrives, bringing color displays to the Macintosh line of computers for the first time.

17 MARCH 1988
Apple sues Microsoft for copyright infringement relating to the Mac OS and Windows interfaces.

20 SEPT 1989
The Macintosh Portable becomes Apple's first battery-powered Mac. Despite the critical acclaim, it doesn't sell well.

The influence of Steve Jobs

Steve Jobs' impact on gamers is still felt today. Here are just a few of the developments he was involved in…



APPLE MACINTOSH

The Macintosh was a huge influence during the 1980s and has continued to evolve. At the time, it was the first commercially successful computer to feature both a mouse and a GUI.

APPLE II

The Apple II was first released in June 1977 and had various revisions. Many American developers, such as John Romero, Richard Garriott, and Jordan Mechner learned to code on it.

PIXAR

Formed in 1979 as the Graphics Group, Steve Jobs bought Pixar Studios from Lucasfilm in 1986, eventually selling it to Disney for roughly $7.4 billion, making him Disney's largest shareholder.

iPOD

The iPod not only revolutionized the way we listened to music but also the music industry itself. As with many Apple products, it was continually refined over the intervening years until streaming eventually took over.

iPHONE

The iPhone had a massive impact on the mobile phone market and was one of the first devices that genuinely allowed you to play 'proper' video games without any fiddly buttons.

iPAD

Apple's iPad wasn't the first tablet device to hit the market. However, it did change the way tablet devices were perceived by the general public. The original iPad was a huge success and it has since sold millions of units.

© WIKIMWDIA

and Mac-like. The MacPlay label was born. But, from a games perspective, the port was something the Mac would now only rarely escape from.

As years passed, the Mac solidified its hold on desktop publishing and creative industries but ceded most other ground to PCs. "And as a big fan of the Mac and an avid games player, I became frustrated that I couldn't play more games," says Peter Tamte, who co-founded MacSoft to redress the balance. His team approached publishers to license rights and bring their games to the Mac. "After showing how these games generated profits for their original publishers and brought in new fans without diluting their PC revenues, we were able to bring more games to the Mac from a wider selection of developers."

Apple wasn't blind to these issues, and there had been efforts to boost Apple's profile in gaming. Craig Fryar worked in evangelism at Apple during the 1990s and exposed senior management to key games. "When they saw the likes of *PGA Tour* and *Sim Ant*, they were amused. The point wasn't lost on them that games could show off a system's horsepower."

Things began to change and Fryar says he was able to secure hardware to feed to developers, along with demonstrating new technology in exchange for games incorporating key features. One example was *Hellcats Over The Pacific*, a flight sim developed by Parsoft Interactive: "They were shown a system that could support multiple monitors out of the box. In return for them getting the hardware, they created a three-display 180° version of *Hellcats*, which was great for showing off the system. We got serious bragging rights because at the time this just wasn't possible on a PC."

Erik Klein was working as an evangelist at the time and remembers a slow turnaround in perception. "Games companies fondly remembered the Apple II days but didn't think they could make money on the Mac. It was a difficult task because you had new audiences to market

21 OCTOBER 1991
Three new PowerBooks, with dark grey cases and built-in trackpads, provide a blueprint for notebooks.

16 AUGUST 1993
Digital assistant Apple Newton is released. Innovative but flawed, it would be axed by Steve Jobs in 1998.

25 OCTOBER 1993
Macintosh TV is Apple's first crack at integrating computers and televisions. But few are made and sold.

14 MARCH 1994
Power Macintosh arrives, based on the PowerPC processor created by AIM (the alliance of Apple, IBM, and Motorola).

28 MARCH 1996
Pippin appears to universal indifference. Apple's first stab at gaming hardware is quickly discontinued.

7 FEBRUARY 1997
Apple finalises a deal to acquire NeXT, bringing Steve Jobs back to the company he co-founded just 12 years after he left.

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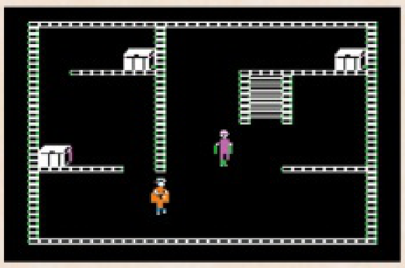
Core gaming

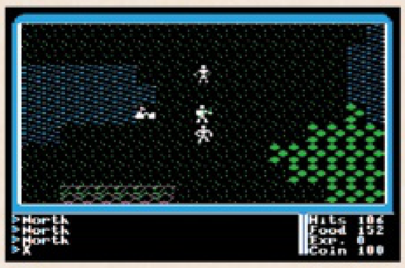
Ten games that defined Apple systems



CASTLE WOLFENSTEIN

APPLE II •1981

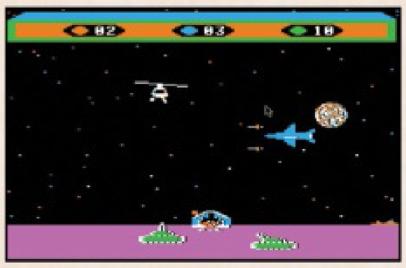
Silas Warner's game is set inside a castle during World War II. Its combination of tense moments, strategy, and arcade smarts won fans over.



ULTIMA

APPLE II •1981

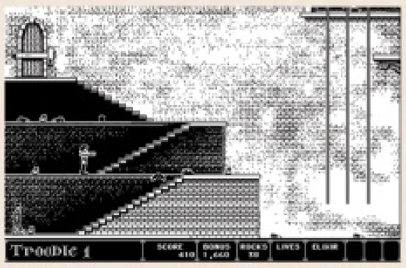
Richard Garriott used his Apple II to make *Ultima*. One of the first open-world RPGs, it has influenced countless games over the years.



CHOPLIFTER

APPLE II •1982

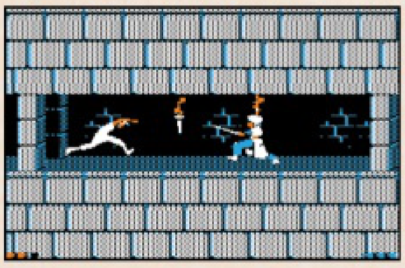
It started as an experiment in creating a controllable helicopter on an Apple II, but *Choplifter* later integrated *Defender*-style rescues.



DARK CASTLE

MAC •1986

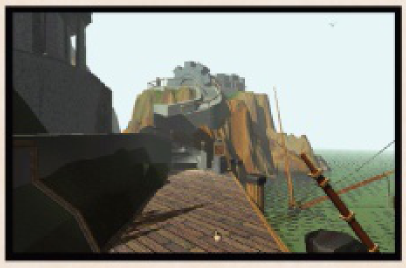
This game was one of the first to take advantage of Mac hardware, using the keyboard for movement and the mouse to launch projectiles.



PRINCE OF PERSIA

APPLE II •1989

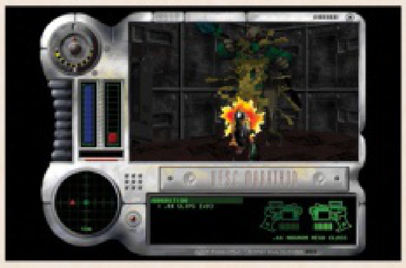
Find your way out of dungeons to save a princess in Jordan Mechner's *Prince Of Persia*. Realistic animation cemented the game's classic status.



MYST

MAC •1993

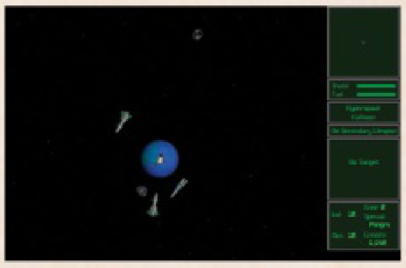
This adventure puzzler started life on the Mac, the release of QuickTime during development enabling the integration of video sections.



MARATHON

MAC •1994

Bucking the trend for static and staid games, *Marathon* brought cutting-edge FPS action to the Mac, combining blasting with a detailed plot.



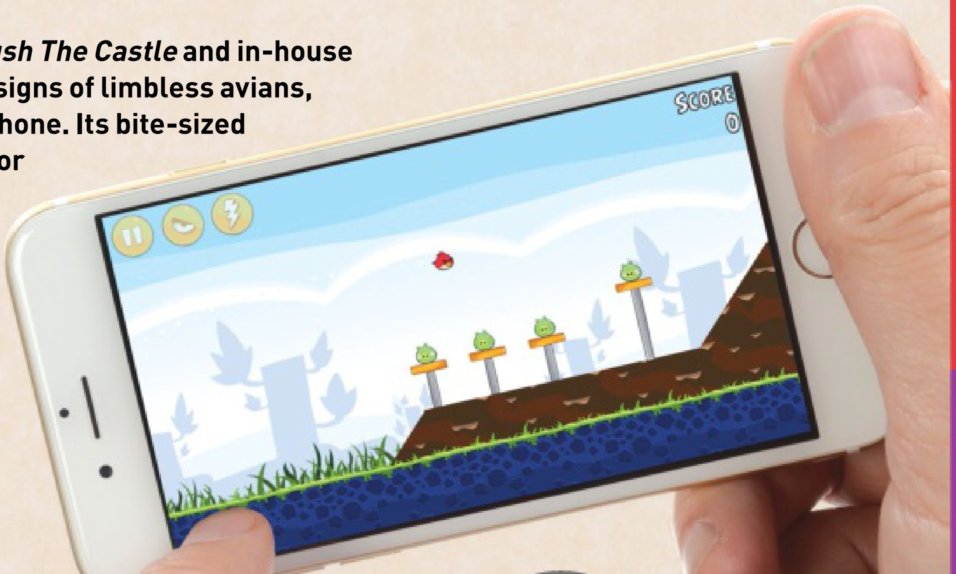
ESCAPE VELOCITY

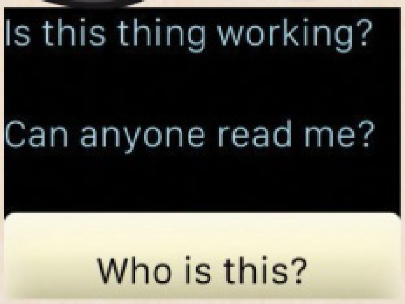
MAC •1996

***Escape Velocity* is a space trading game that resembles *Elite*, with a third-person view during the outer-space travel sections and battles.**

ANGRY BIRDS *iOS •2009*

Inspired by online flash game *Crush The Castle* and in-house Rovio designer Jaakko Iisalo's designs of limbless avians, *Angry Birds* exploded on to the iPhone. Its bite-sized slingshot gameplay was perfect for touchscreen control, catapulting the game toward iconic status.





Is this thing working?

Can anyone read me?

Who is this?

LIFELINE *Apple Watch •2015*

A new generation of game, *Lifeline* works better on Apple Watch than a smartphone. Essentially, you assist a stranded astronaut with a compelling and emotional narrative—playing it on a watch feels oddly futuristic.

7 MARCH 1997
The Apple eMate, based on the earlier Newton model, is the company's attempt to appeal to the education market.

20 MARCH 1997
The Twentieth Anniversary Macintosh is released. It outlines the shape of future consumer tech.

7 AUGUST 1997
Microsoft comes to the aid of a struggling Apple, giving it a cash injection to boost competition.

15 AUGUST 1998
Apple wows the tech industry with the audacious iMac G3. Its translucent shell becomes a meme.

21 JULY 1999
The iMac goes mobile with the iBook, a colorful, friendly notebook with surprisingly advanced tech smarts.

19 JULY 2000
The Power Mac G4 Cube proves a step too far regarding combining design and computing. Sales are disappointing.

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Pipsqueak
Apple vs. its rivals

Pipsqueak

APPLE VS. MICROSOFT

Microsoft started out as an Apple ally but Windows drove a wedge between the companies. Apple fumed at Microsoft's perceived plagiarism, but many lawsuits later Apple was almost bankrupt. In 1997 Microsoft injected cash and shored up its ailing rival, seemingly to retain 'competition'. Apple subsequently blazed past, predicting and driving consumer hardware trends in a way Microsoft couldn't match.

Pipsqueak

APPLE VS. IBM

Big Blue killed any hope Apple had of mainstream success in the 1980s. The PC's arrival in 1981 provided an affordable alternative to Apple's offerings. But, over time, the rivalry thawed, showcasing the tangled relationships between tech companies. For years, PowerPC chips from an Apple/IBM/Motorola alliance were found in Macs. Today, Apple and IBM are increasing the iPad's corporate reach together.

Pipsqueak

APPLE VS. SAMSUNG

In one of the oddest modern-day tech relationships, Samsung and Apple are butting heads and yet are reliant on each other. Samsung still manufactures many Apple device components and has long been 'inspired' by the iPhone and iPad. Additionally, Samsung's TV ads often rip into Apple, arguing its customers are brainless fools taken in by marketing. Long-term, expect Apple to split entirely from Samsung.

Pipsqueak

APPLE VS. DELL

One of the most famous tech quotes of all time occurred in 1997 when Dell CEO Michael Dell claimed that if he was put in charge of Apple, he would "shut it down and give the money back to the shareholders". He now argues that his words were misunderstood and that he was mulling from the position of still being Dell CEO. Still, it showcased a stark difference in thinking between the two organizations.

Pipsqueak

APPLE VS. ADOBE

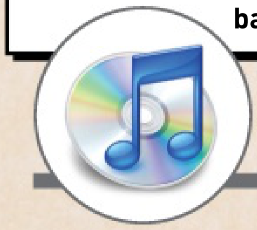
Once, Apple and Adobe were close, but as Apple's grip on the design industry loosened and Adobe became more bullish, cracks appeared in the relationship. Steve Jobs refused to support Flash on iOS, arguing it was unstable—Adobe accused Apple of restricting freedom, however, Flash was terrible on mobile. Apple won the battle and Flash's online presence is diminishing.

to, different channels to sell the product, and different press to woo. But we proved there was a market, which almost doubled in terms of sales during my time at the company. This was especially the case during the transition to PowerPC chips, which helped the Mac become a powerful system that could run state-of-the-art PC ports."

Although ports remained the most common kind of Mac game, the platform did get the occasional first. Pioneering immersive CD-ROM adventure *Myst* debuted on the Mac, mainly because it had been developed on the platform using HyperCard (a localized proto-web, with a card-based system housing interactive components) and Apple's QuickTime video technology. Another first was *Marathon*, an innovative and exciting FPS that you'd have expected to land on the PC.

Bungie co-founder and *Marathon* developer Alexander Seropian was drawn to the Mac because of how visual it was. "I was jealous of all the games you could get on the PC. Gaming on that platform was growing, and there was this pent-up demand for games on the Mac that wasn't being addressed." Hence *Marathon*? "I'd like to say that was a conscious strategy on our part, but the reality is the Mac was what we used and liked, so we chose to work there out of convenience more than anything else," he admits. "But the Mac community was receptive to *Marathon*. We'd travel the country visiting user groups and going to Macworld shows. We met many gamers who helped inform what we were putting into the game."

Far from an also-ran, *Marathon* helped define what an FPS could be. It focuses more on narrative, using levels to tell a story, and had one of the earliest 'free look' systems. Naturally, it became a major influence on Bungie's *Halo*, although it didn't go as far as to revolutionize Mac gaming. Instead, Mac ports increasingly arrived as PC originals hit the bargain bin and, in 1996, Apple made a misstep with its only full foray into Mac-based dedicated gaming hardware, the risible



9 JANUARY 2001
iTunes appears, initially as an MP3 player. It would later evolve into a cornerstone of Apple's strategy.

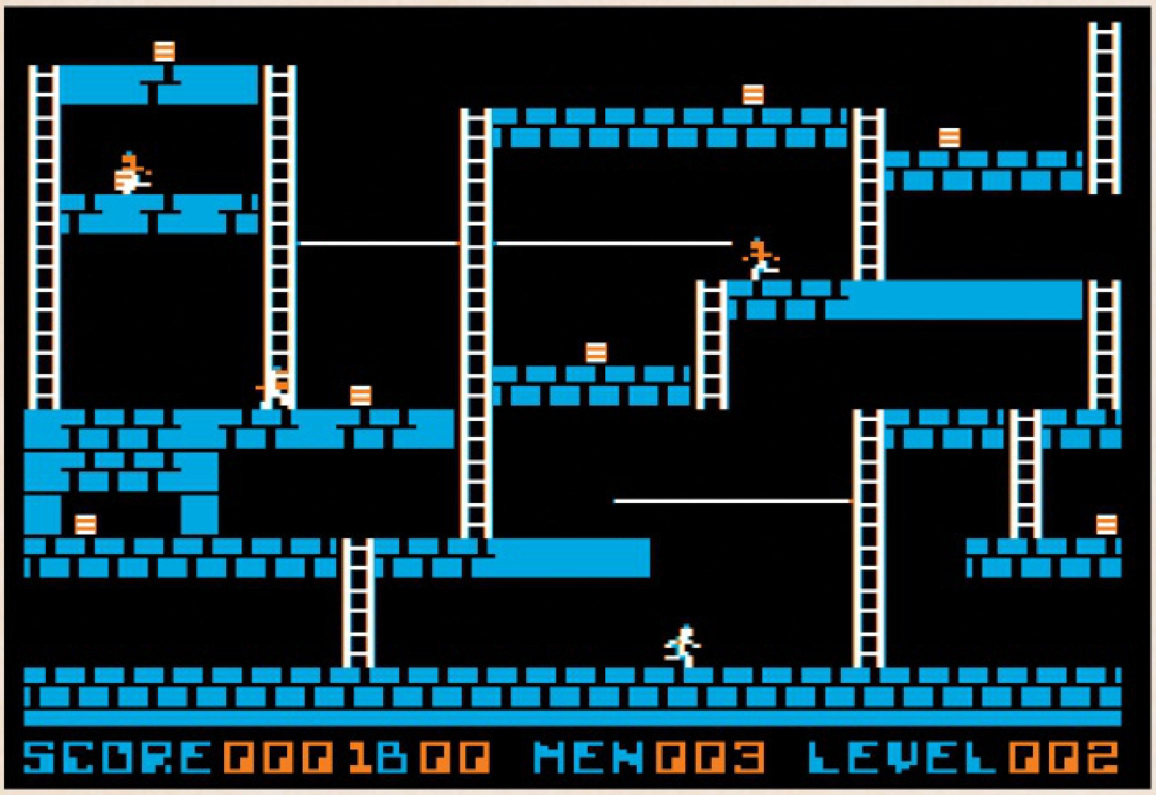
23 OCTOBER 2001
Apple revolutionizes portable music playing with the iPod, which betters existing players for UI and storage.

31 AUGUST 2004
The iMac goes all-in-one, essentially becoming a monitor with a chin. All subsequent iMacs follow this design.

9 JANUARY 2007
Apple TV kickstarts Apple's so-called 'hobby' product, aiming to compete with PVRs for the space under your TV.

29 JUNE 2007
iPhone upends the entire mobile phone industry, with a revolutionary interface that others soon clamor to copy.

15 JANUARY 2008
Steve Jobs pulls a notebook out of an envelope at a keynote event. MacBook Air invents the term 'Ultrabook'.



The superb *Lode Runner* from 1983 is one of the Apple II's most recognizable games.

Pippin, which was poorly architected, overpriced, and lacking in both developer support and consumer interest.

At the time it looked like Apple might disappear as buy-out rumors circulated. According to Pangea's Brian Greenstone, developers left in droves, which was good for Pangea and a few others that became big fish in a small pond. But questions were being asked whether Apple could recover. Its future looked bleak.

However, it was co-founder Steve Jobs who saved Apple from the brink. Having quit the company he founded in 1985, he returned in 1997, ruthlessly culled a messy product line, and set Apple on the course it's on today. A leaner Apple prized high-quality hardware that appealed to consumers and pros alike. From a games perspective, the Mac never bounced back. "By the time Apple recovered, there was no one left, except for a few companies porting two-year-old PC games, and a few still making original Mac games," says Greenstone. "Games development had gotten so expensive and the Mac's market share was so small that it wasn't feasible to keep developing games for it."

It would need an entirely new platform to transform Apple's fortunes in gaming. Initially dismissed by the tech industry and pundits alike as an overpriced trinket, the Apple iPhone and its multitouch display was an instant hit with consumers. The groundbreaking smartphone marked a turning point in the industry, changing how you interacted with devices. Initially, third-party apps weren't part of the picture, although a community flourished to support 'jailbroken' iPhones freed from Apple's restrictions. A year after the iPhone's release, all bets were off: the App Store arrived and with it a gold rush that the software industry had never before experienced.

Steve Demeter's *Trism* used the iPhone's accelerometer, the player moving triangular tiles about in a variation on popular match puzzlers. Within two months, Demeter had made over $250,000 from an investment of some spare time and paying a designer $500. Elsewhere, rhythm game *Tap Tap Revenge* hit a million downloads two weeks after launch, reaping huge rewards from in-game advertising. Major developers also clambered on board, trying to make sense of this new platform, Sega perhaps doing so most successfully with a tilt-based *Super Monkey Ball*. The trickle became a flood, and suddenly Apple found itself with not quite a games platform but a platform people were playing a lot of games on.

Sometimes, the tide turned. Apple struggled with censorship issues, banning titles for seemingly arbitrary reasons. A small handful of games began to dominate the charts, making life tough for indies. And then free-to-play mechanics spread throughout the platform like a virus, robbing many games of their purity.

Even so, iOS (the platform that now encompasses iPhone, iPod Touch, and iPad) has many positives. Not only for Apple, given that the games category is typically the App Store's most profitable, but also for developers. Veteran coder Ste Pickford says that iOS lacks gatekeepers in the way most other platforms don't. "There's no concept approval, where someone decides whether or not your game can be released. We became indies because we wanted the freedom to design video games without being limited to what marketing departments wanted to sell." Vlambeer's Rami Ismail adds that iOS remains a way to potentially reach a huge audience, without massive investment: "There are few barriers to entry, although the platform has a problem with clones, which can seriously knock your motivation if your game is ripped off."

Apple is setting its sights on the living room again, with the Apple TV. The little black box is far from revolutionary, but could it herald another gaming revolution from the company? "It's ironic that in the Mac days, gaming was such a low priority for Apple, but now with its mobile systems, gaming is the biggest usage and revenue driver on those platforms," says Alexander Seropian, now CEO of mobile games developer Industrial Toys. "Things have changed, and while a flooded market means it's a lot harder to get noticed, it's still a great time to be making games. And Apple is a major player in that ecosystem." ⏻

10 JULY 2008
The App Store radically transforms the scope of the iPhone, ushering in an age of mainstream mobile apps.

3 APRIL 2010
iPad is launched. Essentially an oversized iPhone, it kickstarts a revolution in tablet computing.

5 OCTOBER 2011
Apple co-founder Steve Jobs passes away at the age of 56, having battled pancreatic cancer since 2003.

24 APRIL 2015
The Apple Watch, a hybrid watch/iPhone is launched. It is Apple's first foray into wearable computing for the masses.

26 OCTOBER 2015
The fourth-generation Apple TV brings Apple apps to your telly, games sharing progress with their iOS siblings.

11 NOV 2015
The launch of the iPad Pro with its new Apple Pencil positions it as not only a high-end iPad but also a device for creators.

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FESTIVE GIFT GUIDE

Whether you're splashing out or need a stocking filler, these are ideal gifts for the PC lover in your life this holiday season

THE FESTIVE SEASON is about spending time with family and friends, but it's also a great time to be dropping hints about what new toys you'd like to receive when the gift-giving commences. Thankfully, the elves here at *Maximum PC* have scoured the market for the best presents for PC lovers this year, whether that's yourself or someone you love.

Our guide covers everything from the high-end to the bargain basement. From complete systems to mice, there's something for every kind of computer lover this December. We've categorized our picks into each type of PC user, so whether you're shopping for a gamer, a creative type, or a road warrior, there'll be something here to make them happy.

As always, we'd love to know what you think of our list, so if you have any suggestions, email editor@maximumpc.com and we'll include them in our Christmas issue, out on 6th December. Happy Holidays!

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THE STREAMER

If you like to show your gaming skills off to the world, create your own YouTube tutorials, or just give your Zoom calls a presentational upgrade, then these are the presents to ask for. Lights, camera, action!

ELGATO STREAM DECK MINI

The Elgato Stream Deck Mini not only gives livestreams the controllability of a TV studio setup, but it's also an excellent productivity tool. You can customize buttons to switch between a game and a webcam in a livestream, control your smart home, or switch between email client and web browser in Windows. Once you get used to this nifty device, it's difficult to live without it. ***$80, www.elgato.com***

SPLASH THE CASH

AVERMEDIA PW513 LIVE STREAMER CAM 4K

While 1080p is enough for most streamers, why not up the production quality with a 4K webcam? AVerMedia's PW513 uses a Sony Exmor sensor for excellent video quality and has a 94° ultra-wide angle lens so you can fit lots in the frame. There's also a privacy shutter and a stand that swivels the camera 360°, meaning you can quickly switch the focus elsewhere. ***$170, www.avermedia.com***

LOGITECH LITRA BEAM

Logitech's new lighting system is interesting. The Litra Beam is lightweight, versatile, and powered using a USB-C cable, either from your computer or a wall adapter. It offers five shades of lighting from warm to cool and you can combine multiple beams to add more depth to yourself and your background with Rembrandt lighting. The Litra Beam can also be controlled using Bluetooth from your phone or an app on your PC. ***$100, www.logitech.com***

HYPERX SOLOCAST

HyperX makes great gaming peripherals and, at $35, this budget USB microphone exudes quality. It only supports vocal pickup from the front of the mic—all that most streamers need—and sound quality is every bit as good as HyperX's more expensive offerings. It comes with an adjustable stand, a bracket for arm-mounting, and a mute button for focusing on the game. ***$35, www.hyperx.com***

STOCKING FILLER

© ELGATO, AVERMEDIA, LOGITECH, HYPERX

THE GAMER

The biggest and best games are released at the end of the year, which makes it a great time to upgrade your setup for maximum enjoyment. These items will all give your gaming rig a significant boost.

STEAM
PC | MAC | STEAMOS

STOCKING FILLER

STEAM DIGITAL GIFT CARD

There are many places to buy games on the PC, but none as ubiquitous as Steam, which beat the Epic Games Store in our October issue's head-to-head. Get prepared for the post-Christmas sales with a digital gift card, available in denominations between $5 to $100. The gamer in your life can spend it on in-game items and subscriptions, such as EA Play, giving them new titles to play in 2023. ***$5-$100, store.steampowered.com/digitalgiftcards***

RTX 4090
GEFORCE RTX

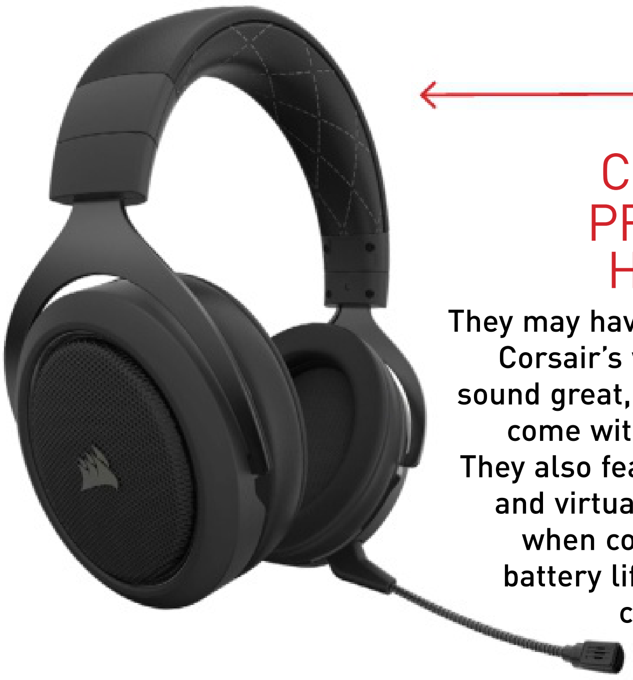
SPLASH THE CASH

NVIDIA RTX 4090

For gamers, Nvidia's latest graphics silicon is at the top of the wishlist this year. The RTX 4090 (see our review on page 74) boasts twice the performance of the previous generation 3090 Ti at the same 450W power consumption, comes with 24GB of GDDR6X memory, and can run almost anything in 4K high settings. You might have to bribe Santa to get your hands on one, though. ***$1,600, www.nvidia.com***

RAZER ENKI GAMING CHAIR

Razer's gaming gear is good, but its new Enki chair range is especially worthy of praise. This all-day chair for work and play has a built-in lumber arch for comfort, supports up to 300lbs, and comes with a three-year warranty. Buy it from Razer and you also get a Viper Ultimate wireless mouse, worth $150. ***$400, www.razer.com***



CORSAIR HS70 PRO WIRELESS HEADPHONES

They may have a budget price, but Corsair's wireless headphones sound great, are solidly built, and come with a crystal clear mic. They also feature noise canceling and virtual 7.1 surround sound when connected to a PC. The battery life isn't great, but you can charge them via a USB cable. ***$80, www.corsair.com***

SAMSUNG 990 PRO 2TB SSD

While we await the first PCIe 5.0 SSDs next year, the best of the Gen4 drives has arrived in time for the holiday season. Samsung's 990 Pro offers a 55 percent performance increase over the 980 Pro, particularly games such as *Forspoken*, which will load maps in around a second. The drive will also run cooler than previous generations, helping longevity. ***$310, www.samsung.com***

V-NAND SSD
990 PRO
PCIe 4.0 NVMe M.2 SSD
www.samsung.com/ssd
SAMSUNG ELECTRONICS CO., LTD.
1TB
SAMSUNG

© DESIFOTO/GETTY IMAGES, NVIDIA, SAMSUNG, CORSAIR, RAZER, STEAM

THE CREATIVE TYPE

Do you know a designer, photographer, or videographer who uses their PC for artistic purposes? Maybe they're looking to turn their passion into their business in 2023? Then help get them off on the right foot with these great gifts.

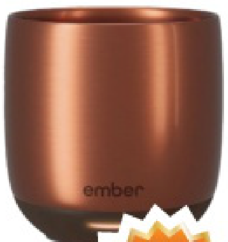
Sunday, October 18, 2020
Up early and another great
walk before sunrise, cool
light and breeze

REMARKABLE 2

Anyone who loves writing on paper but with the safety of cloud backup will love the reMarkable 2. It's designed to replicate the feeling of real paper, thanks to its unique design with a tactile, scratchy feel. You can write on PDFs, make notes that are automatically transcribed into documents, and draw doodles that are backed up to the cloud. You can then access them on any device you like, plus share or edit them. ***$279, www.remarkable.com***

GOVEE GLIDE HEXA LIGHT PANELS

These light panels add a splash of color to any home office while creating interesting patterns and shapes. They slot together with ease and attach to the wall with non-destructive adhesive, then use the mobile app to create light shows or set moods. It works with every smart assistant going, including Alexa and Google, and even plugs into Razer's Chroma RGB system. ***$120 (7-pack), $150 (10-pack), www.govee.com***



STOCKING FILLER

EMBER CUP

Editing photos, videos, or documents can be a long process so a little pick-me-up can keep you going. Ember's cup is designed for cappuccinos, cortados, and flat whites, keeping your drink at the right temperature for when you need it. The built-in battery keeps the temperature you set in the app for up to 1.5 hours—or all day if you use the included charging coaster. ***$100, www.ember.com***

SAMSUNG GALAXY TAB S8 ULTRA

While the Apple iPad Pro is also a good choice, Samsung's Android equivalent is a better option for designers and other creators. Unlike the iPad, it has a higher quality OLED display, features a huge 14.6-inch screen, and comes with a brilliant stylus that's ideal for sketching, drawing or writing.

It also now boasts Android 12L, the large-screen variation of Google's OS, making it easier than ever to multitask on that huge screen. ***$835, www.samsung.com***

SPLASH THE CASH

© GOVEE, EMBER, SAMSUNG, REMARKABLE

MAKE YOUR OWN PROJECTS WITH THE RASPBERRY PI

Learn the electronics, computing, and coding skills you need to make your own projects with the Raspberry Pi, and let your imagination run wild

Practical
NEW
Raspberry Pi Projects
Get hands-on with your Raspberry Pi
Assemble a robot arm
Create a virtual reality setup
Drive a remote control car
HTML 5
Updated for Raspberry Pi Model B 4
Program a Raspi-powered synth
Control Minecraft with a power glove
Attach screens and other accessories
Fly your own quadcopter
Get to know the world's smallest computer
CUSTOMISE YOUR PI
BUILD INCREDIBLE GADGETS
PROGRAM AMAZING SOFTWARE
ISBN 978-1-83850-390-1
FUTURE
FIFTH EDITION
Practical Raspberry Pi Projects Fifth Edition

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FUTURE

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THE NOVICE

Some people just want to have a great PC experience without needing any technical knowledge. These are the gifts you can give to a novice, so they can have all the fun without the fuss.

STOCKING FILLER

MICROSOFT 365 FAMILY

Keep the whole family backed up with Microsoft 365 Family, which offers 1TB of cloud storage for up to six people. Important files automatically sync to the cloud, while mobile users can install the app to automatically back up photos and videos. You also get premium versions of the Office apps, plus 50GB of Outlook email storage, 60 minutes of free Skype calls, and premium tech support. ***$100 per year, www.microsoft.com***

LENOVO G27C-10 CURVED GAMING MONITOR

You don't have to spend a fortune to get a great monitor with all the features a gamer needs. Lenovo's G27c-10 is a 27-inch panel with plenty of screen real estate, has a 165Hz refresh rate for silky smooth gaming, and supports FreeSync for smooth, tear-free visuals. It's also curved for an immersive experience and, at 1080p resolution, it looks good without needing a $1,000+ graphics card to power it. ***$270, www.lenovo.com***

HP OMEN 25L

HP's Omen 25L desktop has everything you want in a modern PC—it's good value, powerful, and even features customizable lighting. For this price, HP offers an RTX 3050 GPU and 8GB of RAM paired either with an AMD Ryzen 5 5600G or an Intel Core i5-12400 CPU. It's ideal for web browsing, working, and playing games at 1080p. ***$949, www.hp.com***

SPLASH THE CASH

HP VICTUS 16

HP's Victus line is a reminder that you can get an awesome laptop that will do everything you need out of the box for less than $1,000. It has a nice big 16.1-inch 144Hz Full HD screen, a beastly AMD Ryzen 7 CPU, an RTX 3050 Ti graphics processor, 16GB of RAM, and 512GB storage.

The Victus 16 will tear through work, games, and anything else you can throw at it, plus store lots of videos, games, and documents. ***$1,000, www.hp.com***

© HP, LENOVO, MICROSOFT

THE PRODUCTIVITY WHIZZ

Know someone who's a spreadsheet superhero, a word processing wizard, or an email expert? These gifts will allow them to become even more productive and, hopefully, enjoy a little bit of luxury at the same time.

FLEXISPOT E7 STANDING DESK

The best standing desk you can buy, according to our sister publication *Creative Bloq*, the E7 has an LED display with four height presets, dual-powered motors, and an alarm to remind you to take a break. It will also support up to 100kg, which is enough for your PC, multiple monitors, and any books you like to keep on your desk. It's also great for tall people, as it extends up to 50-inches. ***$580, www.flexispot.com***

STOCKING FILLER
belkin

BELKIN BOOSTUP WIRELESS CHARGING STAND

If you're sitting at a desk all day, keep your smartphone ready to go with this wireless charger. Its 10W of power is enough to charge about 30 percent battery per hour and is compatible with Apple and Android phones. It's a standing charger, which allows you to read notifications or glance at your new iPhone 14 Pro's always-on display. ***$35, www.belkin.com***

SAMSUNG ODYSSEY NEO G9

If you're running multiple programs at once, an ultrawide setup can boost productivity. The Odyssey Neo G9 takes this to extremes with its 5120x1440 resolution screen, the equivalent of two large monitors. Its Quantum Mini-LED panel is extraordinary, as is the 240Hz refresh rate. ***$1,675, www.samsung.com***

SAMSUNG
Odyssey Neo G9
SPLASH THE CASH

LOGITECH MX MASTER 3S MOUSE

Those who spend all day with a computer will love this mouse. It feels great in the hand, has a highly accurate 8K DPI sensor, and every one of its buttons and wheels can be customized on a per-app basis. But the killer feature is being able to work across systems, copying a file from your Mac and pasting it on your PC, for example. ***$100, www.logitech.com***

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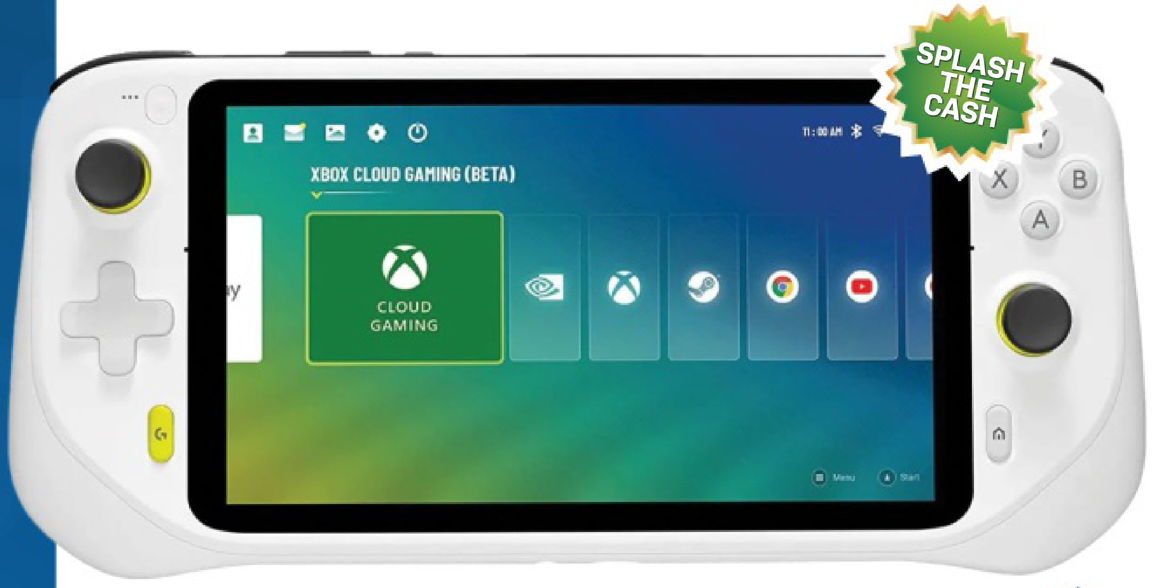
THE ROAD WARRIOR

If someone you know is constantly on the move, they don't have to forgo comfort or enjoyment with these brilliant portable gifts. Whether it's work or pleasure, these products will make life on the road that bit more enjoyable.



LOGITECH G CLOUD GAMING HANDHELD

Logitech's portable gaming system allows you to stream games from cloud services, such as Xbox Cloud Gaming and Nvidia GeForce Now, plus Xbox Remote Play and Steam Link. Using a hotel Wi-Fi connection, you can then play your games library with proper gaming controls and haptic feedback. Games look great on the 7-inch 1080p 60Hz display, it weighs just over 1lb and has a long 12-hour battery life. ***$300, www.logitech.com***

SPIGEN 120W USB-C CHARGING STATION

Spigen's USB-C power station offers 100W charging from a single USB-C port—that's enough to charge a laptop—plus 15W from its USB-A port for a mobile phone or tablet. This compact and lightweight device can also charge two USB-C devices at once, at 60W each. ***$60, www.spigen.com***

STOCKING FILLER

QGEEM USB C TO HDMI 4K ADAPTER

If you know a frequent traveler, this gift will make those nights away more enjoyable. It connects to any modern laptop, Android device, or newer Apple iPad Air/Pro and allows you to output videos, games, or even work on the hotel room television using an HDMI cable. You can also use it to make higher-quality video calls to the family back home. ***$11, www.qgeem.com***

HYPERX CLUTCH WIRELESS CONTROLLER

If you're out and about, you'll want to have some downtime wherever you are, whether that's on a plane or in a hotel room. Gamers will love the HyperX Clutch Wireless Controller because it connects to everything, including your computer, tablet, and mobile phone, with an included clip to hold a phone securely. That means you can play on your PC or stream from Xbox Cloud Gaming on your mobile device. ***$40, www.hyperx.com***

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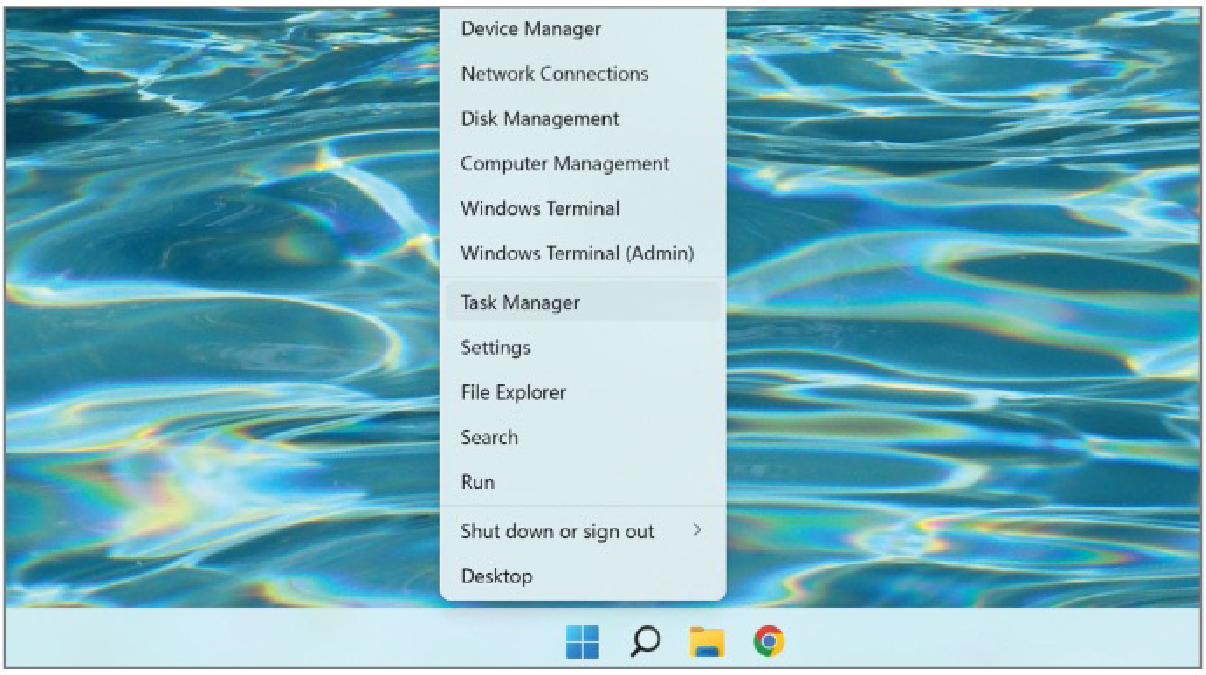
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH

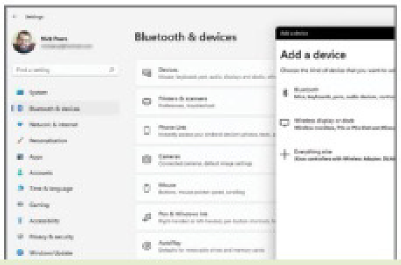

Device Manager
Network Connections
Disk Management
Computer Management
Windows Terminal
Windows Terminal (Admin)
Task Manager
Settings
File Explorer
Search
Run
Shut down or sign out
Desktop

SECRET START MENU

Everyone knows how to access the Start menu, right? (Click on the Windows icon at the bottom left of your screen or on your keyboard, just in case). But are you aware that there is a lesser-known menu from which you can access the command prompt, task manager, and control panel? Right-click on the Start menu or press 'Windows key + X' to open this secret menu and reveal these important Windows tools.

MAKE – USE – CREATE

62
Tearing down the new Apple Watch Ultra with iFixit.


Bluetooth & devices
Add a device

64
Manage your hardware within Windows 11.

AVATAR
Avatar

68
Organize your media server by adding metadata.

© MICROSOFT, IFIXIT, JELLYFIN

SAM LEWIS
STAFF WRITER

SAME OLD 'BEEP'

Am I growing out of video games? Or are my expectations too high? I ask myself these two questions every time I get excited about a new title only to be, somewhat inevitably, let down.

The latest *Saints Row* certainly hasn't lived up to its predecessors. So, did that cloud of nostalgia for the old games obscure my view? Possibly, but it's more a feeling of being stuck in a continuous cycle of looking forward to new releases, then getting bored far too quickly. When I was younger, games had a far longer lifespan than any recent titles I've been playing.

Unfortunately, that is the case with *Saints Row*. Rinse and repeat missions, floaty driving mechanics, and a lack of originality all plague this latest entry in the franchise. It's a shame, because as I've mentioned before, I played these games like there was no tomorrow on the PlayStation 3.

There are some fun, quirky moments and customization, so it's not all doom and gloom, but it left me feeling "meh". That's not exactly what I had in mind when the nostalgia struck beforehand. At the time of writing, *Call of Duty Modern Warfare 2* is on the horizon. I'm hoping this doesn't get hit by the same cycle of hype and subsequent deflation.

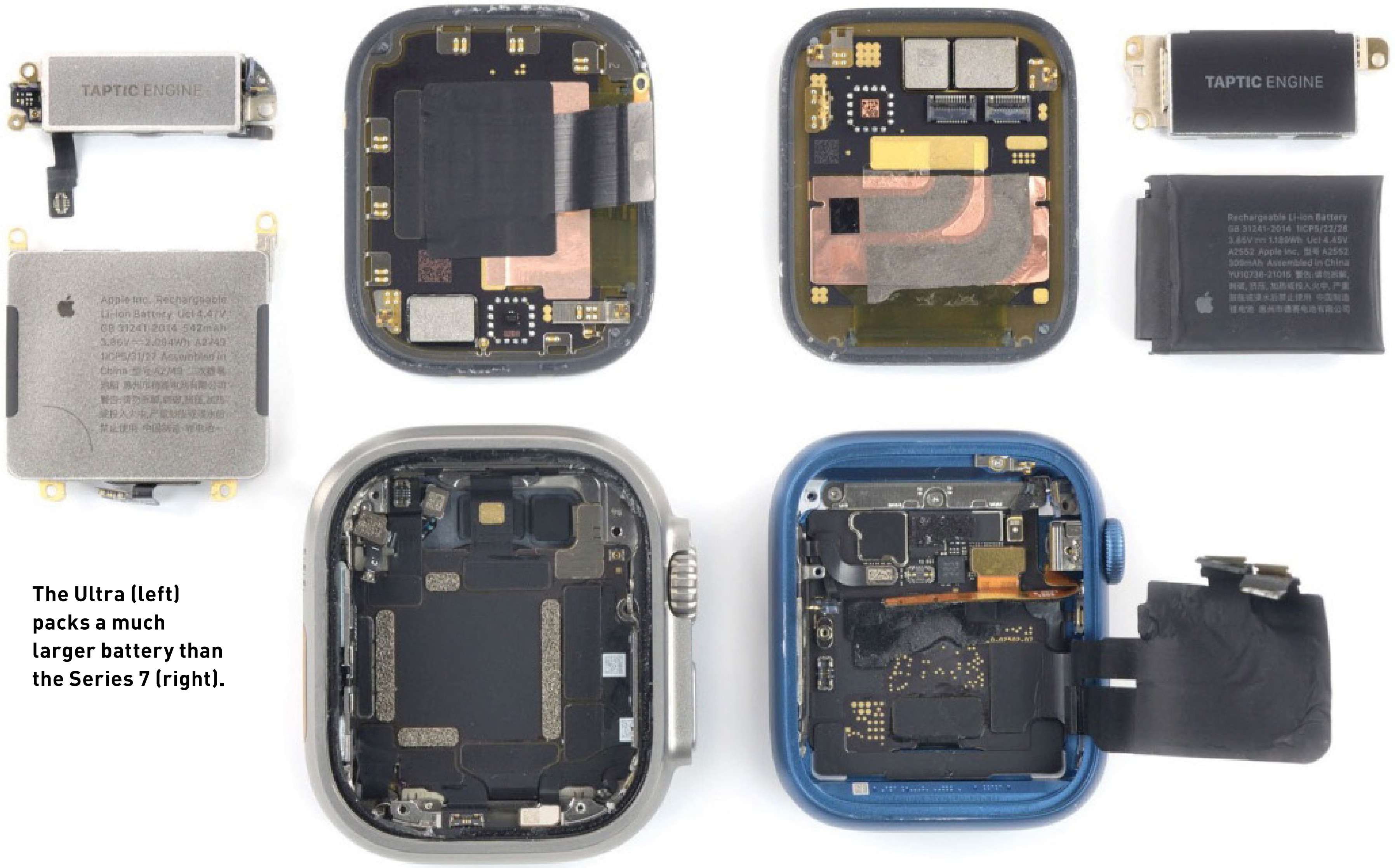
↘ submit your How To project idea to: editor@maximumpc.com

IFIXIT
presents:

AUTOPSY

THIS MONTH WE DISSECT...

Apple Watch Ultra

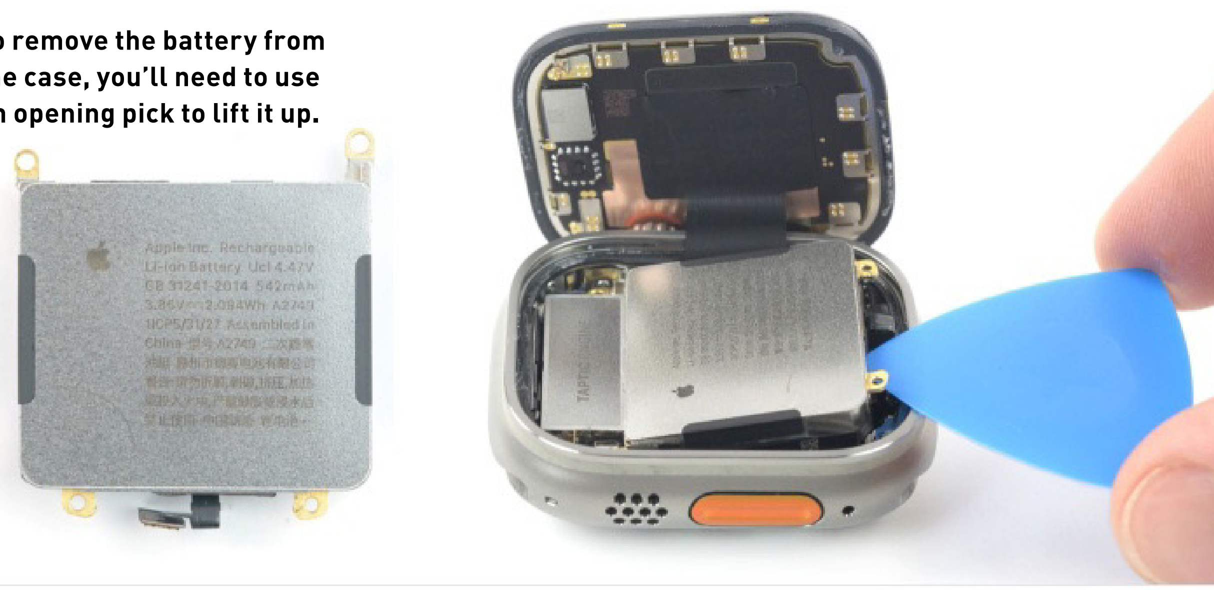


The Ultra (left) packs a much larger battery than the Series 7 (right).

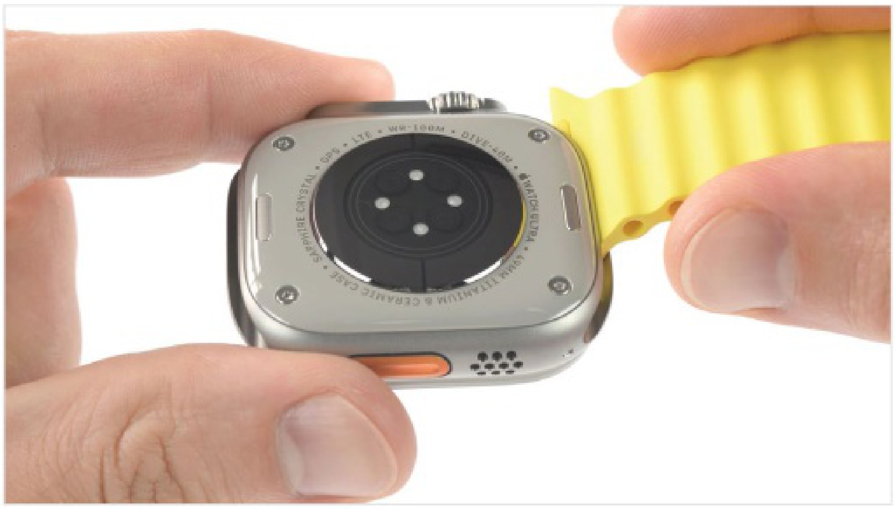
About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products.
To learn more, visit www.ifixit.com

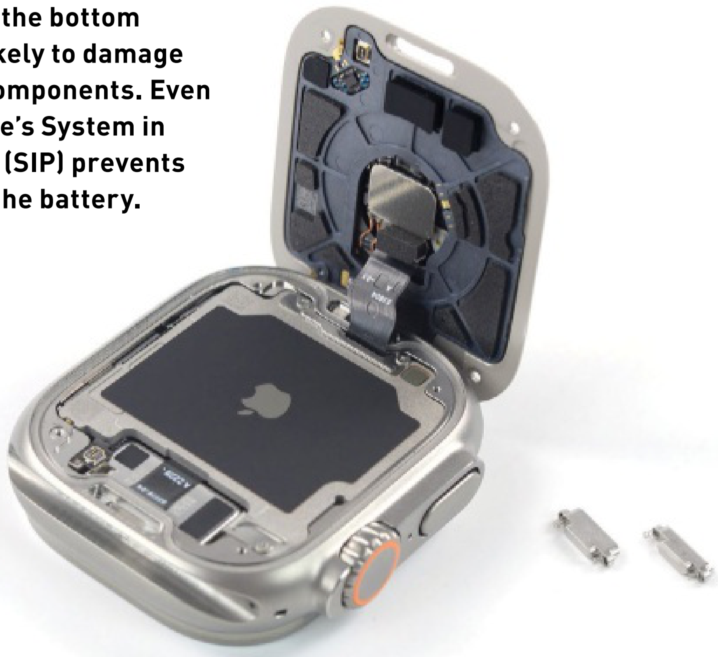
To remove the battery from the case, you'll need to use an opening pick to lift it up.



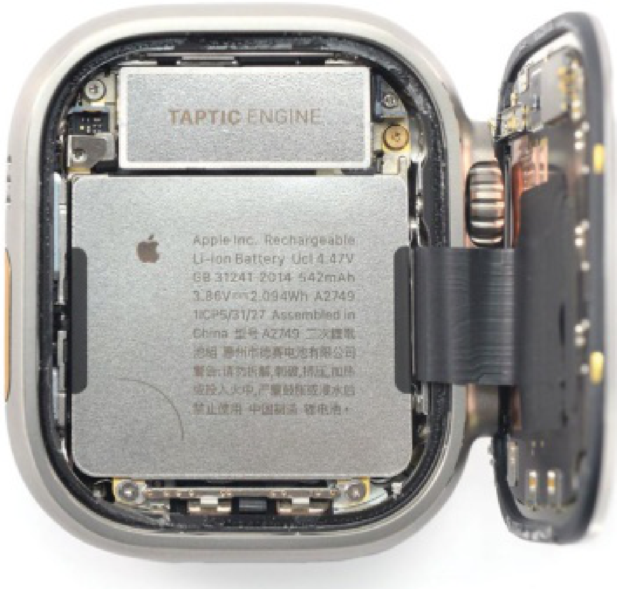
Before starting repairs, take your watch off the charger and power it down.



The Ultra is sealed using four screws, a first for an Apple Watch. Though they are fiddly pentalobe screws, it's better than glue.



Removing the bottom panel is likely to damage internal components. Even then, Apple's System in a Package (SIP) prevents access to the battery.



Lifting up the screen is incredibly tough and requires a good opening tool and lots of patience. You'll need to do it though, as it's where the battery is held.

BACKGROUND

Apple's first extreme sports wearable promises 'ultra' everything, from durability to battery life and features. Whether you're climbing a mountain or diving in an ocean, Apple's watch is built for exploring.

MAJOR TECH SPECS

- Screen: 49mm
- Display: 410x502 pixels, 2000 nits brightness, Always-On OLED
- Storage: 32GB
- Chips: S8 with 64-bit dual-core processor, W3, U1
- Connectivity: LTE and UMTS8, Wi-Fi, Bluetooth 5.3
- Battery life: Up to 36 hours (Wi-Fi), Up to 18 hours (LTE)
- Siren: 86 decibels
- Water resistance: 100m
- Diving depth: 40m
- Weight: 61.3g

KEY FINDINGS

- This is the first Apple Watch to be accessible using screws, albeit the fiddly pentalobe variety. Maybe Apple appreciates this watch is more likely to need fixing? But the party is short-lived, as removing the back shreds the clear gasket Apple has used to aid waterproofing. Replacing this won't be fun at all.

- There's more bad news. After applying some heat to pry off the rear of the case, one of the band release button springs comes flying out. And all that's revealed is Apple's System in a Package (SIP), which blocks all access to the watch's internals. It means that to access the battery, we have to go in via the front display.

- We applaud the ease of accessibility on the back of the watch, but all it's good for is replacing the sensor module that goes against the wearer's wrist. Like the iPhone 14, these changes seem to have been made to improve the experience for Apple Geniuses repairing in-store, but battery swaps will require specialist equipment or, more likely, need to be sent away.

- That means we need to go through the front to get to the other internal components in this watch. Getting through a standard Apple Watch's front display is challenging, but the Ultra is extra-durable. The seams are tight, the prying angle is steep, and the risk of separating the display from the glass is high.

- Release the display from the body, however, and you're straight into the battery. Apple has used the same metal casing for the battery that it's been using in its smaller-model watches since the Series 5. It protects the battery and uses four Y000 screws to secure it rather than glue, which is preferable for repairers.

- Opening previous watches also destroyed a gasket responsible for Force Touch, which is not the case on the Ultra. While Apple deserves credit for these concessions, it should be criticized for the cost of repairs—a battery replacement costs $99, while 'Other damage' is $499. If you're likely to be putting it through its paces, we'd look at the $99 AppleCare+ package.

- There are other interesting discoveries. The Taptic Engine is huge—50 percent bigger than on the standard Series 8, and at 9.8g, 16 percent of the watch's overall weight. The speaker has a dual 'split' design, one for the Siren and one for the regular speaker end. Apple boasts of 86 decibels from the siren, which sounds impressive but is only as loud as an alarm clock.

- Repairability score: 3 out of 10 (10 is easiest to repair). From an engineering perspective, the Apple Watch Ultra is an incredible product, particularly the crazy-complex case that houses the antennae and depth sensor. However, the difficulty of accessing the battery is a problem for hobbyist fixers. Though you can replace the rear glass and sensor, you risk losing or breaking parts in the process. Everything else requires you to open from the front and risk shattering that fancy OLED screen.

Manage hardware with Windows 11

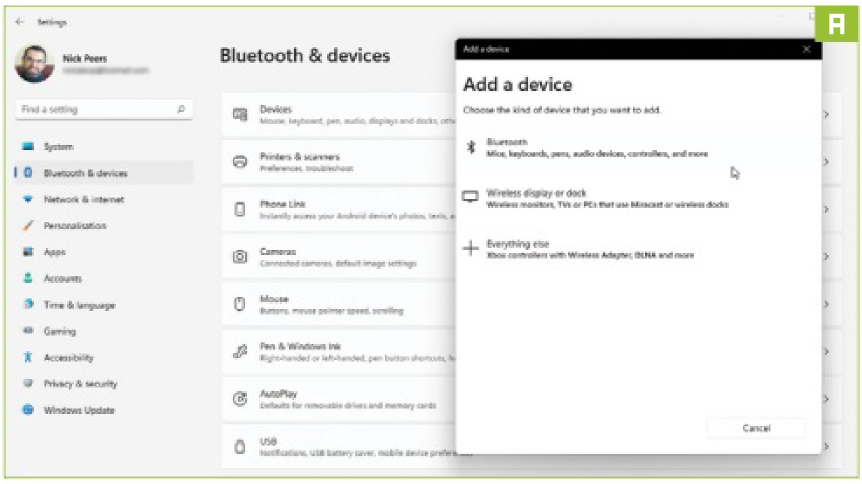
YOU'LL NEED THIS

HWiNFO
(www.hwinfo.com)

WI-FI ANALYZER
(https://matthafner.com/wifi-analyzer)

KEEPING TABS ON THE VARIOUS COMPONENTS and peripherals that make up your PC's hardware can be a time-consuming task, but Windows 11 has you covered. The operating system has long offered a myriad of tools for managing and tweaking your hardware but has traditionally struggled to make them easily accessible and sensibly organized.

Microsoft has pulled more options into the Settings app, so most of what you need is under a single section (Bluetooth & Devices), with shortcuts to other key areas (such as your display and network settings) clearly labeled. It's not all good news—some key settings remain in their previous locations, but Microsoft has removed easy shortcuts. In this tutorial, we'll take you on a tour of the Windows 11 Settings app, revealing how to access those hidden tools, and where to turn when you need functionality and help not offered in Windows 11 itself. **–NICK PEERS**


A
Settings
Nick Peers
Find a setting
System
Bluetooth & devices
Network & internet
Personalisation
Apps
Accounts
Time & language
Gaming
Accessibility
Privacy & security
Windows Update
Bluetooth & devices
Devices
Printers & scanners
Preferences, troubleshoot
Phone Link
Cameras
Connected cameras, default image settings
Mouse
Buttons, mouse pointer speed, scrolling
Pen & Windows Ink
AutoPlay
Defaults for removable drives and memory cards
USB
Add a device
Bluetooth
Mice, keyboards, pens, audio devices, controllers, and more
Wireless display or dock
Wireless monitors, TVs or PCs that use Miracast or wireless docks
Everything else
Xbox controllers with Wireless Adapter, DLNA and more
Cancel

Add a device

Choose the kind of device that you want to add.

1 EXPLORE WINDOWS SETTINGS

There are three main areas to explore when tweaking hardware using Windows 11's Settings tool: System, Bluetooth & Devices, and Network & Internet.

›› Bluetooth & Devices covers all wireless and wired external devices except your display. There are eight sections—the annotation provides a quick summary of what to expect from some of the more self-explanatory ones. At the top, you'll find Devices, complete with an 'Add device' button.

›› Click this to pair Bluetooth devices or other wireless tech to your PC, such as Miracast-streaming TVs and displays [**Image A**]. To set up an Android phone, use the 'Open Phone Link' button instead.

›› Click Devices to get a broad overview of your PC's key components and peripherals. Individual devices can be removed here, but there's little else of interest until you scroll down to discover shortcuts to Sound, Display, and somewhat surprisingly, the classic Devices and Printers Control Panel (see step five).

2 CONFIGURE AUDIO DEVICES

One welcome improvement in Windows 11 is the incorporation of the old Sound Control Panel and related tools such as Volume Mixer into the main Settings tool. It can be accessed directly via System → Sound. Here you'll find options to configure both output (speakers and headphones) and input (microphones) devices.

›› Thanks to the breadcrumbs navigation system at the top of the Settings window, it's a lot harder to get lost than with previous versions of Windows. Select a device to tweak its properties, from simple volume control to enabling advanced features.

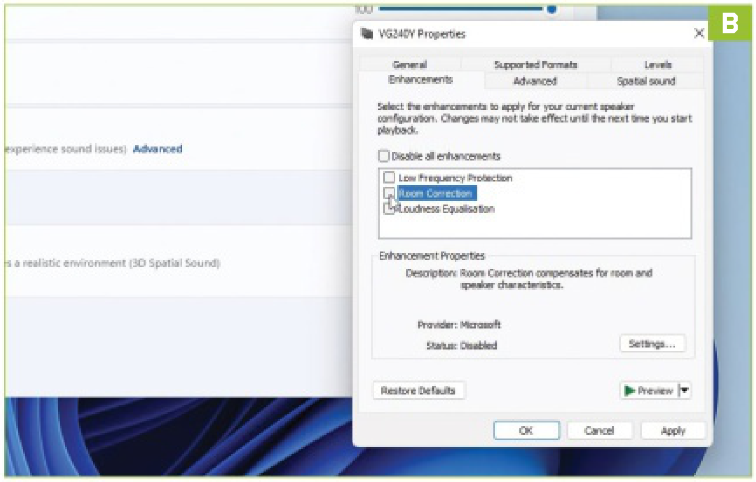
›› There are still rare occasions when clicking an option (such as Advanced under 'Enhance audio') will bring up the device's own Properties screen [**Image B**]. For the most part, though, you can now access virtually everything you need to set up, configure and troubleshoot your speakers, headphones, and microphone from one location. And if all else fails, or you're a stickler for old-school dialogs, click 'More sound settings' from the main screen to access the classic Sound Control Panel.

3 TWEAK DISPLAY SETTINGS

Visit System → Display under Settings and you'll find a set of controls for configuring your graphics adapter and monitor. This covers the fundamentals, such as desktop resolution and refresh rate, plus handy brightness and color tools. Use 'Night light' to reduce eyestrain at night, and here you'll find settings like HDR for supported games, apps, and crucially, displays.

›› Attach a second monitor and a new Multiple displays section appears at the top of the Displays tool. Use the 'Show only on…' dropdown to extend or duplicate the display, then use the Identify button to locate each display if necessary. From here, click and drag one of the displays to reconfigure its layout. For most people that simply involves making sure the displays align to their physical layout on your desk, but you can also place displays on top of each other for more complex setups.

›› Scroll down to the Advanced display section to change the display's refresh rate or select Graphics to configure graphics settings on an app-by-app basis. In


B
VG240Y Properties
General
Supported Formats
Levels
Enhancements
Advanced
Spatial sound
Advanced
Enhancement Properties
Settings...
Restore Defaults
Preview
OK
Cancel
Apply

experience sound issues) Advanced

s a realistic environment (3D Spatial Sound)

Select the enhancements to apply for your current speaker configuration. Changes may not take effect until the next time you start playback.

☐ Disable all enhancements

☐ Low Frequency Protection
☐ Room Correction
☐ Loudness Equalisation

Description: Room Correction compensates for room and speaker characteristics.

Provider: Microsoft

Status: Disabled

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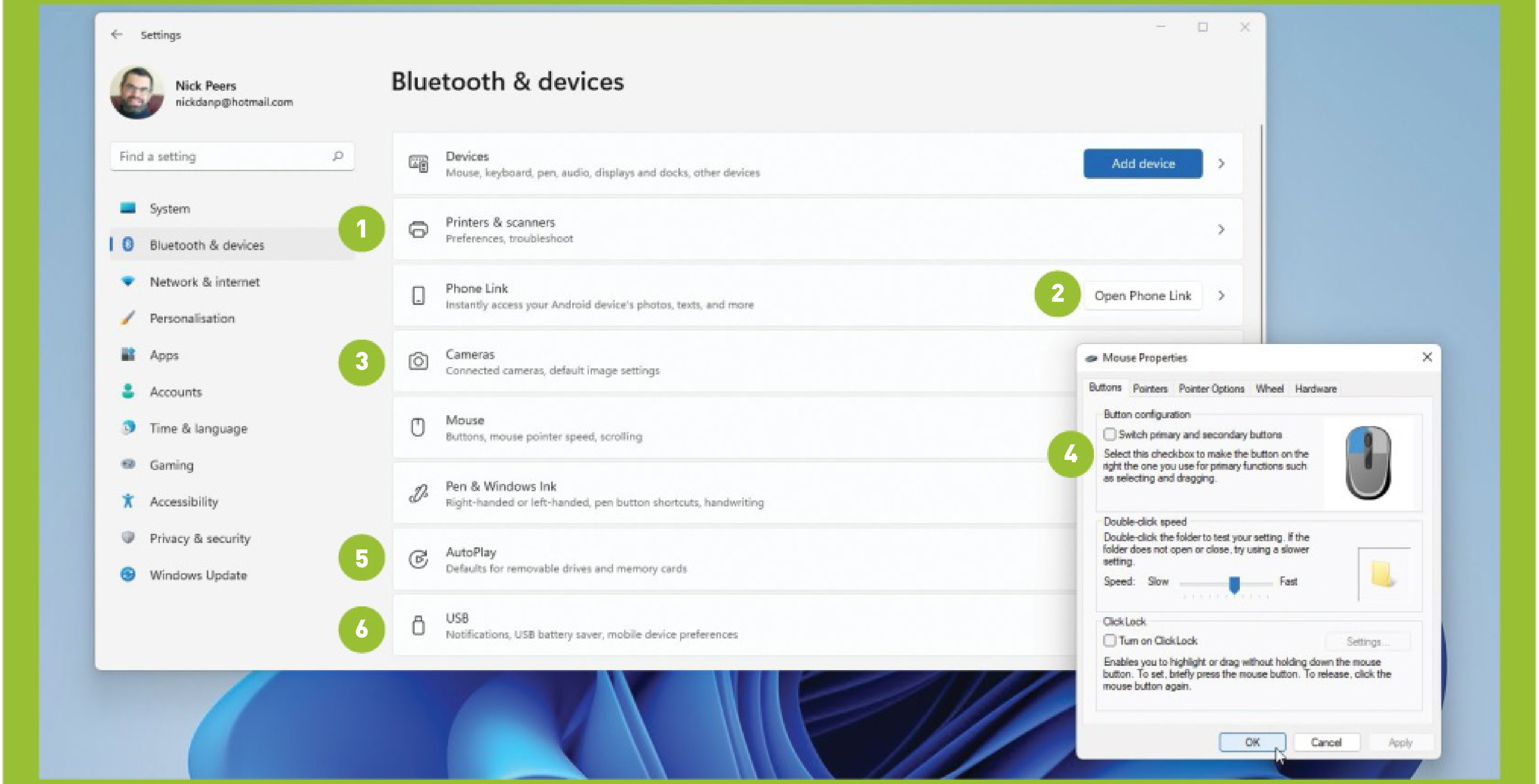
TOUR BLUETOOTH & DEVICES


Settings
Nick Peers
nickdanp@hotmail.com
Find a setting
System
Bluetooth & devices
Network & internet
Personalisation
Apps
Accounts
Time & language
Gaming
Accessibility
Privacy & security
Windows Update
Bluetooth & devices
Devices
Mouse, keyboard, pen, audio, displays and docks, other devices
Add device
Printers & scanners
Preferences, troubleshoot
Phone Link
Instantly access your Android device's photos, texts, and more
Open Phone Link
Cameras
Connected cameras, default image settings
Mouse
Buttons, mouse pointer speed, scrolling
Pen & Windows Ink
Right-handed or left-handed, pen button shortcuts, handwriting
AutoPlay
Defaults for removable drives and memory cards
USB
Notifications, USB battery saver, mobile device preferences
Mouse Properties
Buttons
Pointers
Pointer Options
Wheel
Hardware
Button configuration
Double-click speed
Speed: Slow
Fast
ClickLock
Settings...
OK
Cancel
Apply
1
2
3
4
5
6

☐ Switch primary and secondary buttons

Select this checkbox to make the button on the right the one you use for primary functions such as selecting and dragging.

Double-click the folder to test your setting. If the folder does not open or close, try using a slower setting.

☐ Turn on ClickLock

Enables you to highlight or drag without holding down the mouse button. To set, briefly press the mouse button. To release, click the mouse button again.

1. PRINTERS & SCANNERS
Click here to not just view installed printers (and install new ones), but access various printer options and change Windows' default setting of choosing your default printer for you.

2. PHONE LINK
Use this to connect your Android phone to your PC so you can instantly access media, send and receive texts, and more. You'll be redirected to the Store to download an app on first use.

3. CAMERAS
View connected cameras (including video cameras) and add new network ones. You can tweak your camera's video and audio from here and, from Windows 11 22H2, apply cinematic effects.

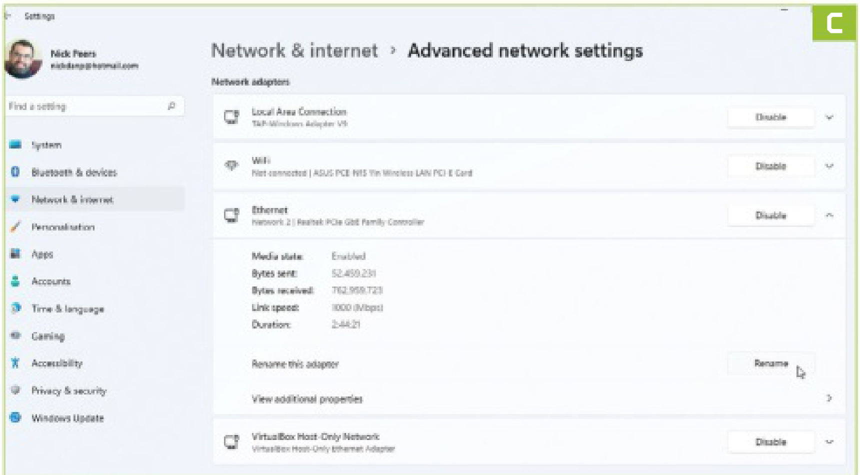
4. MOUSE
Core mouse features are now housed here, such as the primary mouse button and pointer speed. Click 'Additional mouse settings' to access more options via the traditional Mouse Control Panel.

5. AUTOPLAY
Configure what happens when you insert USB drives or memory cards into your PC. By default, AutoPlay is disabled for security reasons, but you can choose specific apps or actions.

6. USB
This section is limited to two on/off options: receive warnings if you run into problems when plugging in a USB device, plus get notified if your PC is charging slowly over USB.

most cases, Windows makes the correct choice between high performance and power saving, but you can make changes here. Click 'Change default graphics settings' for further options, such as hardware-accelerated GPU scheduling, to enable or disable.

›› While the basics are covered in Settings, if you want to dig deeper into your graphics settings, make sure you've installed your manufacturer's drivers. AMD and NVIDIA both provide their own configuration tools, which let you dig even deeper.


C
Settings
Nick Peers
nickdanp@hotmail.com
Find a setting
System
Bluetooth & devices
Network & internet
Personalisation
Apps
Accounts
Time & language
Gaming
Accessibility
Privacy & security
Windows Update
Network & internet › Advanced network settings
Network adapters
Local Area Connection
TAP-Windows Adapter V9
Disable
Wi-Fi
Not connected | ASUS PCE N15 11n Wireless LAN PCI-E Card
Disable
Ethernet
Network 2 | Realtek PCIe GbE Family Controller
Disable
Rename this adapter
Rename
View additional properties
VirtualBox Host-Only Network
VirtualBox Host-Only Ethernet Adapter
Disable

Media state: Enabled
Bytes sent: 52,459,231
Bytes received: 762,959,723
Link speed: 1000 (Mbps)
Duration: 2:44:21

4 GET MORE ACCURATE COLORS

One piece of hardware that's often overlooked when it comes to your PC is your monitor. You plug it in, the picture magically appears, and then once you've set the display resolution, that's pretty much it. However, you may be missing several tricks.

›› Although Windows usually correctly lists your monitor's model when you select 'Advanced display', that doesn't mean you're necessarily running dedicated drivers. In most cases, Windows will simply install a Generic PnP Monitor driver which does just enough to give you access to basic controls like refresh rates.

›› If your monitor came with an installation CD you can try installing drivers from there or locating them online at the manufacturer's website. In most cases, these drivers are tiny—barely 10KB in some cases—and usually comprise a maximum of three files. The INF and CAT files are the actual driver files, while an ICM file is a set of color profile settings that aim to render colors more accurately through your monitor.

›› You can attempt to install these drivers through the Update Driver button in Device Manager under the

FIX YOUR WI-FI CONNECTION

While Windows Settings provides some troubleshooting tools to deal with network problems, one area it can't help you with is the performance of your Wi-Fi network. If you aren't getting the expected transfer speeds or are experiencing frequent dropouts, use the free Wi-Fi Analyzer tool (https://matthafner.com/wifi-analyzer).

Once installed, the app will display a summary of your current connection, including signal strength. A Networks tab provides a list of networks within range (or just outside range), providing you with an idea of how many networks are in your neighborhood and whether they're causing interference.

To confirm this, switch to the Analyze tab to view a chart that displays networks according to the channel they're transmitting on. If Wi-Fi Analyzer detects you could improve your signal by switching to a different channel, it will highlight it. However, the actual change will require you to log on to your router or access point's configuration utility to manually do so.

All core functionality is in the free version, but a Pro version ($3) is worth trying to see if the additional features, including connecting to networks directly from the app, are worthwhile.

monitor's Driver tab. Select 'Browse my computer for drivers' followed by 'Let me pick from a list of available drivers on my computer'. Click the Have Disk... button and browse to the folder containing your driver files. The actual driver should be selected and clicking OK should force Windows to accept your manufacturer's driver as well as the color profile settings.

›› To verify the ICM file has been correctly installed, navigate to Advanced display and click 'Display adapter properties for Display' to open a separate window. Switch to the Color Management tab and click the button to open another window. This should list the monitor's own ICC profile; if it doesn't, tick 'Use my settings for this device', click Add and either select the color profile file from the list or click Browse to manually add it.

5 CONFIGURE YOUR NETWORKS

Visit Network & Internet for an overview of your current network setup. At the top, you'll see your connection type (Ethernet or Wi-Fi), status, and data usage for the past 30 days. You'll also see your network's properties, Public or Private. If you have shared folders, it will be set to Private, but if not, the recommended setting is Public. You can easily connect to other shares, but no one can see your PC in return.

›› Find out more about your network by clicking either WiFi or Ethernet depending on your connection type. You can edit IP and DNS addresses here, but if you need to dig deeper, navigate back to Network & Internet, scroll down and select Advanced network settings. Expand your network interface where you can monitor various stats, plus rename the adapter [Image C].

›› Scroll down to view options to reset your adapters to their initial settings, plus a shortcut to 'More network adapter options' if you're nostalgic for the older Control Panel. You'll be deposited at Network Connections where you can troubleshoot individual connections (select one and click 'Diagnose this connection').

›› Go back to 'Network & Internet' and you'll find a shortcut to the Network and Sharing Centre where you can access 'Media streaming options' (turn your PC into a UPNP device) and 'Change advanced sharing settings', for options such as switching on public folder sharing and disabling password-protected shares.

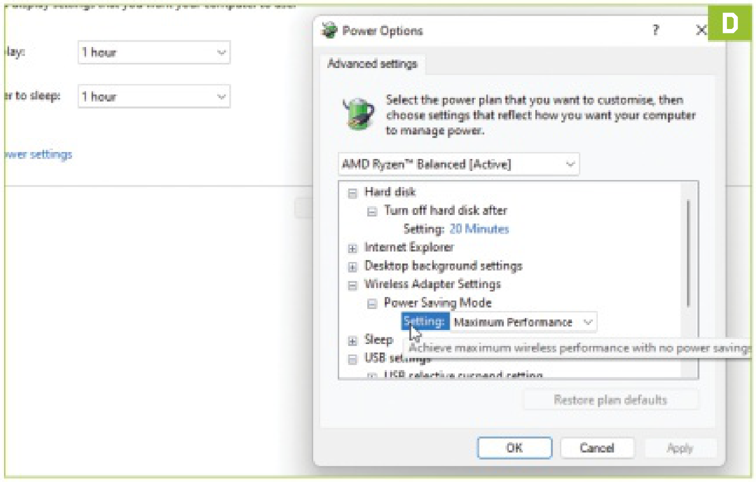
6 TAP INTO LEGACY WINDOWS TOOLS

Despite Microsoft's best efforts, you may still be unable to confine yourself to the Settings tool when it comes to configuring hardware.

›› Device Manager, which is still easily accessible by right-clicking the Start button, remains a crucial tool, primarily for troubleshooting as we explained in these pages in last month's issue. However, it's not the only throwback from earlier versions of Windows.

›› Another leftover feature is the Devices & Printers tool, which first made its appearance in Windows 7. This is accessed directly from the Devices section of Bluetooth & Devices. It provides a visual overview of every single external device attached to your PC, including some additional wireless options, such as UPnP media streaming devices.

›› This is more useful than the Settings tool in that you can right-click each device to access additional options, including direct links to troubleshooters as well as a properties screen. This gives you a summary of the device itself, plus links to all Device Manager entries related to the hardware. That means not just the device, but also any ports it's connected to (such as the underlying USB controller).



lay: 1 hour
r to sleep: 1 hour
wer settings

Power Options

Advanced settings

Select the power plan that you want to customise, then choose settings that reflect how you want your computer to manage power.

AMD Ryzen™ Balanced [Active]

⊟ Hard disk
  ⊟ Turn off hard disk after
    Setting: 20 Minutes
⊞ Internet Explorer
⊞ Desktop background settings
⊟ Wireless Adapter Settings
  ⊟ Power Saving Mode
    Setting: Maximum Performance
⊞ Sleep
⊟ USB settings

Achieve maximum wireless performance with no power savings

© MATTHAFNER.COM/WIFI-ANALYZER

7

MANAGE POWER OPTIONS

If you're a laptop user or looking to troubleshoot power-related problems such as a PC that won't stay asleep, then you'll find the lack of options in Settings (System → Power) disappointing. You are basically limited to setting a time when your display turns off or your PC goes to sleep, plus choosing a power mode (performance, balanced, or power saving).

» Despite the lack of options, there's no easy shortcut provided to the old Power Options Control Panel. The quickest way to get to it is to press Win + R, type powercfg.cpl, and hit Enter. This is where you can set up your own custom power plans or perform minor tweaks to existing settings. To do the latter, click 'Change plan settings' next to the currently selected plan followed by 'Change advanced power settings'.

» This opens a separate window where you can specify individual power settings for different parts of your system [**Image D**]. Here, for example, you can set a time to power down your hard drives after a period of inactivity, plus disable or enable USB selective suspend depending on whether your laptop is plugged in or running on battery. This latter option effectively disables USB ports when the device connected to them is idle to prevent battery drain from devices drawing power from the port.

» Other options include preventing your PC from going to sleep when playing multimedia content as well as disabling 'wake timers', which basically refer to scheduled actions including backups or virus scans. To learn more about each option, simply hover your mouse over its name in the list.

8

TROUBLESHOOT SLEEP AND HIBERNATION ISSUES

The solution to many power-related problems usually lies in tweaking Power Options or seeking out a Power Management tab on a device's properties in Device Manager. But how do you identify the culprit if it's not obvious?

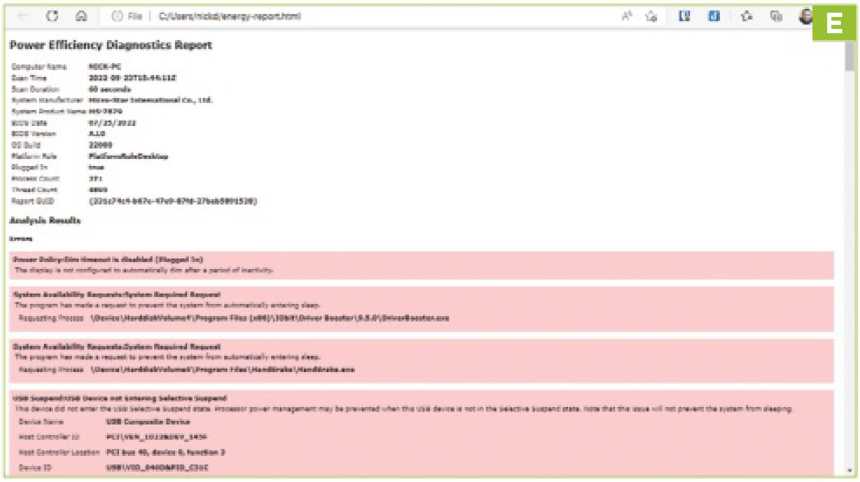
» The solution is a command-prompt tool: powercfg. Right-click the Start button and choose Windows Terminal (Admin) to open a command prompt. If your PC refuses to stay asleep, type powercfg/lastwake and hit Enter to see what last woke it up, then use this as the basis of your troubleshooting.

» To view a list of what drivers and apps can wake your PC, type powercfg /requests, then follow it up with powercfg/waketimers to view a list of services that can do the same.

» If you're still no closer to finding the culprit of your sleep-related woes, generate a detailed report of your energy and power usage by typing the following command:

```
powercfg/energy
```

» The report takes about 60 seconds to generate and is then saved to the root of your user folder as energy-report.html. Double-click it to view it in your web browser, and you'll see a list of 'errors'. These aren't necessarily problems, but among the recommendations for cutting power usage may be clues as to why your PC won't sleep [**Image E**].



Power Efficiency Diagnostics Report

Analysis Results

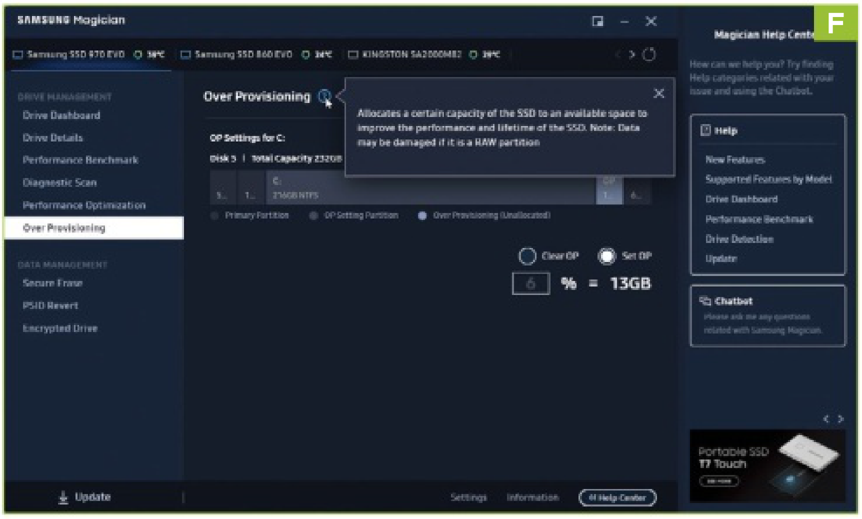
Power Policy:Dim timeout is disabled (Plugged In)
The display is not configured to automatically dim after a period of inactivity.

System Availability Requests:System Required Request
The program has made a request to prevent the system from automatically entering sleep.

System Availability Requests:System Required Request
The program has made a request to prevent the system from automatically entering sleep.

USB Suspend:USB Device not Entering Selective Suspend

© MICROSOFT, SAMSUNG



Over Provisioning

Allocates a certain capacity of the SSD to an available space to improve the performance and lifetime of the SSD. Note: Data may be damaged if it is a RAW partition

OP Settings for C:

○ Clear OP ● Set OP

6 % = 13GB

9

KEEP AN EYE ON YOUR HARD DRIVES

Your hard drives are a key part of your system, so it pays to find ways of keeping a close eye on their performance and health.

» The simplest solution here is to look for a utility from the drive's own manufacturer, such as Magician for Samsung's SSD and NVMe drives (https://semiconductor.samsung.com/consumer-storage/magician/), or Kingston SSD Manager (www.kingston.com/support/technical/ssdmanager).

» You'll find tools for monitoring SMART status, drive temperature, and scanning your drive for errors along with benchmarking to verify that you're getting the performance you expect.

» Here, you'll also find several performance optimizations, including a feature called over-provisioning. Select this and you'll gain extra performance benefits and extend the drive's overall lifespan [**Image F**]—but be aware that this is in return for surrendering up to 10 percent of the drive's capacity.

» Also, keep an eye on potential firmware updates for your drives. Again, these tools provide further means for checking (and updating) your drives. ⏻

GET A DETAILED SUMMARY

One area where Windows still falls short is in providing a detailed summary of your hardware setup. Aside from the listing of processor and RAM under System → Settings → About, you can run the System Information tool for more information, but you won't get much more than you'd find manually trawling through Device Manager.

If you'd like a proper look at your system, we recommend the free version of HWiNFO (www.hwinfo.com). This provides you with two windows: a System Summary provides detailed information about your motherboard, CPU, and GPU while the main screen bears a superficial resemblance to the Components section of System Information but shows much more. Highlights include being able to trace each individual USB device to its parent USB controller and get more detailed information on hardware components and their capabilities.

Click Sensors to monitor in real-time key aspects of your hardware, from voltage and temperatures to the hard drive's SMART status and memory usage. HWiNFO could prove to be an essential part of your hardware toolkit.

Organize your media server

YOU'LL NEED THIS

Two tools feature in this tutorial

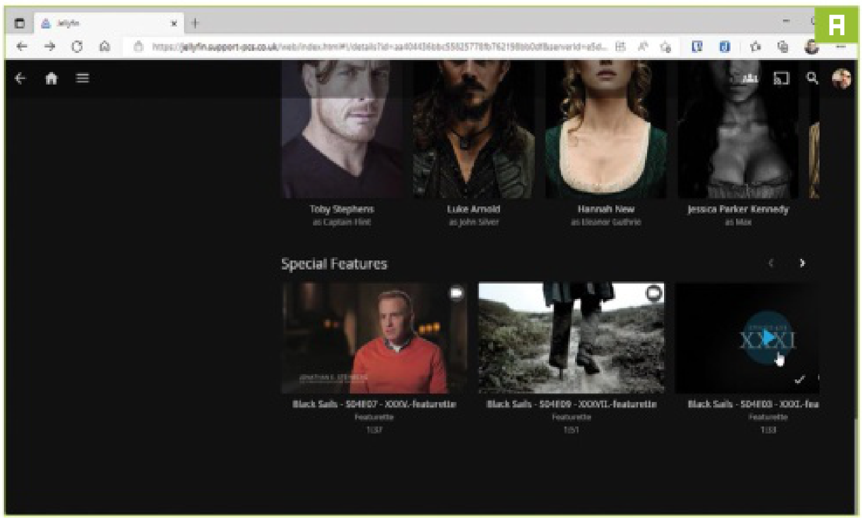
RENAME MY TV SERIES 2
free
(www.tweaking4all.com/home-theatre/rename-my-tv-series-v2/)

METAX FOR WINDOWS
$9.95
(www.danhinsley.com)

THE SECRET TO A PERFECT media server isn't just the creation of files that play nicely with all your streaming devices. All good media servers, including Plex and Jellyfin, perform what's known as 'media scraping' of online databases such as TheTVDB to furnish you with all the metadata you need—title, episode, synopsis, cast, rating, and so on.

In most cases, this process can be done automatically—all you need to do is correctly name files and place them within the specific folder hierarchy. In this tutorial, then, we'll first look at how to both quickly and easily rename and organize your files to make them identifiable to your media server. We say 'most cases', of course, and while your media server can effortlessly handle the bulk of your movies and TV shows, there will be a few exceptions. For example, if you have collected a lot of supplementary material, such as featurettes, deleted scenes, trailers, and so on, then you will need to tag this content manually.

While you could do this using your media server's own tagging tools, in the second part of this tutorial, we'll reveal a better, long-term solution that not only makes the job easier but ensures your media libraries look their best now and in the future. **–NICK PEERS**



1 MOVIE FOLDER STRUCTURES

The good news is that media servers, including Plex and Jellyfin, support the same folder structures, allowing you to switch between them more easily. Let's start with movies. While you can simply store movie files directly into a single library folder, if you create a dedicated folder for each one you can store supplements alongside it. Look at the following structure:

```
Movie Title (Year)
        \Supplement Type
```

» The Supplement Type subfolder can be one of the following (not case sensitive): Behind The Scenes, Featurettes, Deleted Scenes, Interviews, Trailers, Shorts, Scenes, or Other. Any files stored inside these will show up on the movie's own page under Extras listed under their filename (with the supplement type beneath) and an automatically generated thumbnail image. No additional tagging is required as supplements don't get their own page—clicking one simply plays it.

2 TV FOLDER STRUCTURES

Things are slightly more complicated for TV shows, but only by the addition of season-level folders. Here's a basic breakdown of what's available:

```
Show Title
        \Specials
        \Season 1
        \Season 2
                \Supplement Type
```

» Both Plex and Jellyfin allow you to insert supplements at one of two levels: Specials is for global supplements, and any files placed here either require being matched to a corresponding entry on thetvdb.com or manually tagged, as we'll see later.

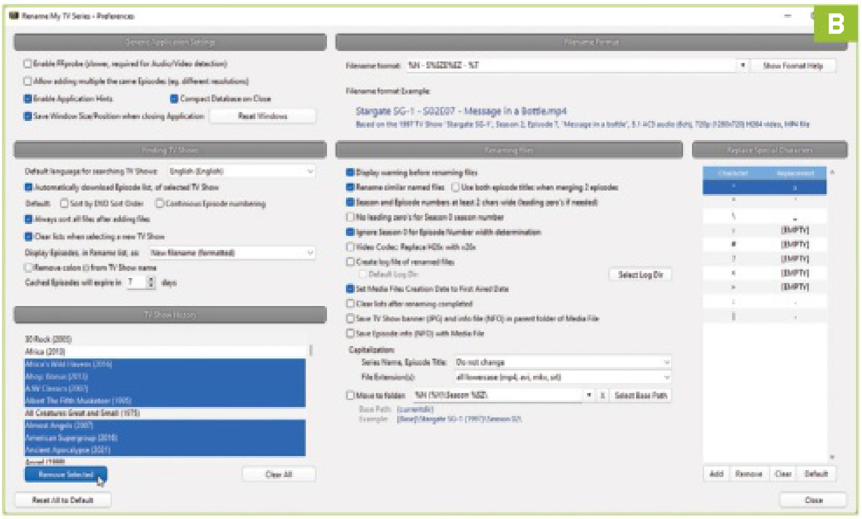
» You can also insert supplements at a season level using the same folder naming convention and structure as movies. All Jellyfin clients can display these, while Plex currently only displays these in select clients, including iOS and Roku. As with movie supplements, these appear beneath the list of episodes and require no additional tagging.

» Plex users gain a third level of tagging: episode-specific supplements. These sit in the same Season folder as the episodes and must be named as follows:

```
Show Name – S01E04 – Episode Title-supplement
```

» Replace 'supplement' with one of -behindthescenes, -deleted, -featurette, -interview, -scene, -short, -trailer, or -other. For example, Battlestar Galactica - S04E09 - The Hub-deleted.mp4.

» If you're a Jellyfin user, you can still name episode-specific supplements in this way, but they currently appear at the season level [**Image A**].



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3 QUICKLY RENAME TV EPISODES

The next task is to name your files correctly. With TV shows, both Plex and Jellyfin accept variations on a theme, but our recommendation is to stick with the TV Show – S00E00 – Episode Title.mp4 convention. Episode Title is optional in these circumstances, but it helps make individual episodes easier to identify as files.

» You can do this by hand, but a simpler option is to employ the services of a free tool designed for this purpose. Head over to www.tweaking4all.com/home-theatre/rename-my-tv-series-v2/ to download and install Rename My TV Series 2. Versions for Windows, macOS, and Linux are available.

» Once done, launch the program. You'll see it's split into four sections. On the left is the TV episodes search tool. The File Renaming Tips sidebar (opposite) reveals the basic steps involved in obtaining the show and episode details you need, then matching those episode titles to the relevant files before renaming them.

» It's all straightforward, and there are some built-in safeguards. If the 'Cannot Rename' button is showing in place of 'Rename Files', then the number of episodes and files don't match. The app will also strip any illegal characters, such as '?', from episode titles before renaming files to ensure they don't cause problems.

4 FINE-TUNE RENAMING SETTINGS

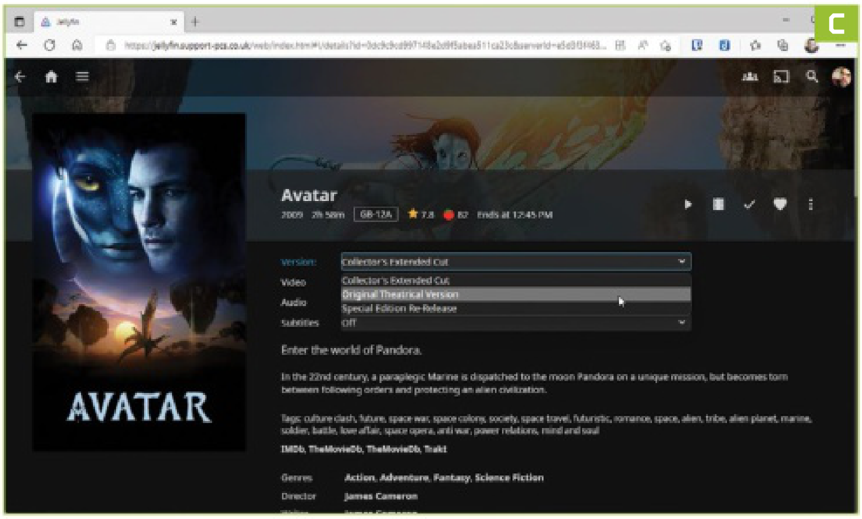
Rename My TV Series 2 provides some additional handy shortcuts. 'Copy TVDB ID' link copies the relevant ID number of the show to the clipboard. This can be handy when trying to track down a stubborn show using Plex or Jellyfin's match tools. Instead of trying to search by name, simply enter or paste the TVDB ID for a perfect match every time.

» You can also use the 'Export Episodes' button to create a text file listing the episodes by season, while Rename My TV Series 2 also stores previously selected shows in the search history. Click the dropdown button next to 'Search' to access this list alphabetically.

» If something isn't to your taste, click the Settings button to change it. There are sections covering the app's general settings, the search tool, and more. You can also edit the search history to remove unwanted entries [**Image B**], change the overall episode naming format as well as fine-tune other parts of the filename, such as capitalization or whether to automatically clear lists after the renaming process is complete. See the File Renaming Tips sidebar for more handy hints and tips.

5 MULTIPLE MOVIE VERSIONS

Sometimes you may want, or even need, to accommodate more than one copy of a film. You might, for example, want to provide two versions of a movie at different resolutions, one for streaming locally (such as 4K) and the other for streaming remotely (1080p or 720p HD). Or you may have multiple releases of the same film—a theatrical edition and a director's cut, for example.



Avatar
2009 2h 58m GB-12A 7.8 82 Ends at 12:45 PM

Version: Collector's Extended Cut
Video: Collector's Extended Cut
Audio: Original Theatrical Version
Special Edition Re-Release
Subtitles: Off

Enter the world of Pandora.

In the 22nd century, a paraplegic Marine is dispatched to the moon Pandora on a unique mission, but becomes torn between following orders and protecting an alien civilization.

Tags: culture clash, future, space war, space colony, society, space travel, futuristic, romance, space, alien, tribe, alien planet, marine, soldier, battle, love affair, space opera, anti war, power relations, mind and soul
IMDb, TheMovieDb, TheMovieDb, Trakt

Genres: Action, Adventure, Fantasy, Science Fiction
Director: James Cameron

© WWW.DANHINSLEY.COM

FILE RENAMING TIPS

Rename My TV Series is a great file-renaming app, and there are several tips and tricks that can help you do even more with it. For example, let's say you have lots of episode-specific supplements—features, deleted scenes, and so on—that you'd like to rename quickly. First, group files of the same type together (so deleted in one folder, featurettes in another). Now, click Settings in Rename My TV Series and add the relevant suffix, such as -deleted or -behindthescenes to the end of the 'Filename format' box. Use the example to verify there's no space between the episode title and the suffix (so Battlestar Galactica – S00E04 - Razor-deleted.mp4). Click Close and match episodes to filenames before renaming them.

You'll also notice some characters are stripped from episode titles in filenames because they're illegal, such as question marks or colons. The Replace Special Characters section of Settings reveals what currently happens with known illegal characters—some are replaced, while others are removed. To change the behavior of a specific character, double-click it in the list and make your changes—for example, you can replace a colon character with a space followed by a dash.

» Both Plex and Jellyfin can accommodate either type through the following naming syntax, though it's more theoretical in the case of Plex:

`Movie Title (Year) – Version name.mp4`

» Version name can be anything you like, so you could go with Avatar (2009) – 4K stream.mp4 or Avatar (2009) – Director's Edition.mp4 to differentiate between the various versions.

» When it comes to accessing movies named this way, however, you're better served as a Jellyfin user. When you browse to the movie's home page, you'll see a conveniently placed Version drop-down menu [**Image C**] allowing you to easily select which version you're looking for.

» Plex users, however, will find certain clients, including the web client, often display limited information (streaming rate, resolution size) about each version, but won't actually allow you to switch between them.

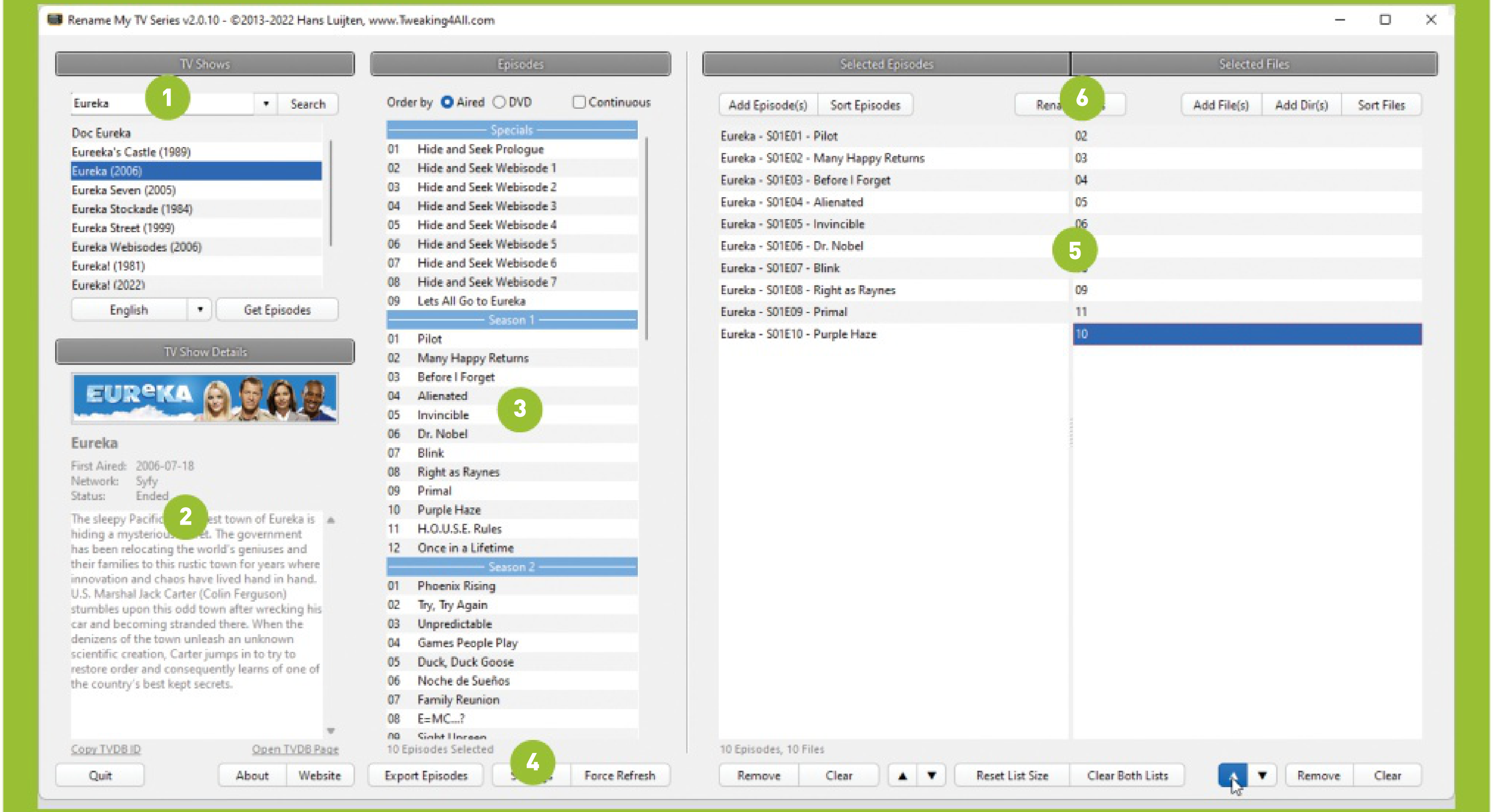
» Other clients, such as the Roku player, can accommodate this, but it's not exactly helpful if you're relying on this approach to differentiate movies by something other than resolution. The sidebar Plex Movie Editions (see page 71) reveals an alternative method that's just been added to Plex.

6 ADD METADATA TO YOUR FILES

So, you've named your files correctly, and in most cases, your media server should be able to identify them and add the appropriate metadata from online sources.

» However, there will always be exceptions, particularly with those TV supplements you want to store in the Specials folder for whatever reason (typically

RENAME TV SHOWS QUICKLY



Doc Eureka
Eureeka's Castle (1989)
Eureka (2006)
Eureka Seven (2005)
Eureka Stockade (1984)
Eureka Street (1999)
Eureka Webisodes (2006)
Eureka! (1981)
Eureka! (2022)

Eureka
First Aired: 2006-07-18
Network: Syfy
Status: Ended

The sleepy Pacific [illegible]est town of Eureka is hiding a mysterious [illegible]t. The government has been relocating the world's geniuses and their families to this rustic town for years where innovation and chaos have lived hand in hand. U.S. Marshal Jack Carter (Colin Ferguson) stumbles upon this odd town after wrecking his car and becoming stranded there. When the denizens of the town unleash an unknown scientific creation, Carter jumps in to try to restore order and consequently learns of one of the country's best kept secrets.

Specials
01 Hide and Seek Prologue
02 Hide and Seek Webisode 1
03 Hide and Seek Webisode 2
04 Hide and Seek Webisode 3
05 Hide and Seek Webisode 4
06 Hide and Seek Webisode 5
07 Hide and Seek Webisode 6
08 Hide and Seek Webisode 7
09 Lets All Go to Eureka

Season 1
01 Pilot
02 Many Happy Returns
03 Before I Forget
04 Alienated
05 Invincible
06 Dr. Nobel
07 Blink
08 Right as Raynes
09 Primal
10 Purple Haze
11 H.O.U.S.E. Rules
12 Once in a Lifetime

Season 2
01 Phoenix Rising
02 Try, Try Again
03 Unpredictable
04 Games People Play
05 Duck, Duck Goose
06 Noche de Sueños
07 Family Reunion
08 E=MC...?

10 Episodes Selected

Selected Episodes	Selected Files
Eureka - S01E01 - Pilot	02
Eureka - S01E02 - Many Happy Returns	03
Eureka - S01E03 - Before I Forget	04
Eureka - S01E04 - Alienated	05
Eureka - S01E05 - Invincible	06
Eureka - S01E06 - Dr. Nobel	
Eureka - S01E07 - Blink	
Eureka - S01E08 - Right as Raynes	09
Eureka - S01E09 - Primal	11
Eureka - S01E10 - Purple Haze	10

10 Episodes, 10 Files

1. FIND A TV SHOW
Type all or part of a show's name and click Search. A list of matching entries from the TVDB website will be displayed.

2. SHOW SUMMARY
Scroll through the list and select the show you're looking for. Verify it's correct using the summary shown here. Click 'Open TVDB Page' beneath the summary to go straight to the website.

3. SELECT EPISODES
A list of episodes, including specials, recorded at TVDB will be displayed. Plex prefers an 'aired' order, so ensure this is selected. Hold Ctrl and click the episodes you wish to highlight.

4. TRANSFER AND SET NAMING CONVENTION
Click 'Add Episode(s)' to transfer the selection here. If you don't like the naming convention (Title – S00E00 – Episode Name) click Settings to change it.

5. MATCH YOUR FILES TO THE RIGHT EPISODES
Next, click Add File(s) or Add Dir(s) to add the files to the list. Match them up using the up and down arrow keys at the bottom of each pane.

6. RENAME EPISODES
Once you're happy that the right episodes are next to the correct files, click the 'Rename Files' button. Click 'Clear Both Lists' to move on to the next batch of files.

to make them more visible or because they're not related to a specific season or episode).

» These latter supplements rarely show up on TheTVDB's database, which means you'll need to manually add whatever metadata you need, and name them so they don't interfere with any existing specials that show up when you perform a search for the show in question.

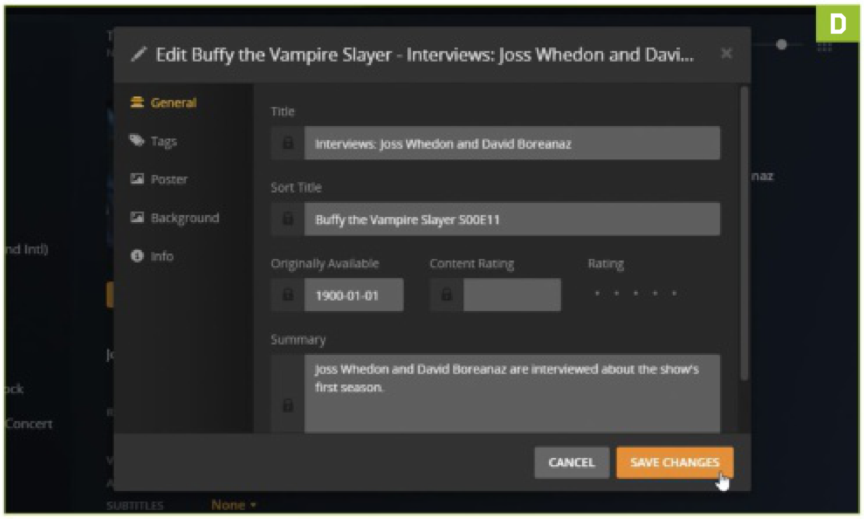
» The best way to avoid any such clashes is to start your episode numbering from 101, such as Buffy the Vampire Slayer – S00E101 – Interviews.mp4, which should ensure that there's no overlap. Now comes the hard part—inputting all the data you need for your media server to display useful information about the supplement in question when it's selected.

» One way you can do this is through your media server. Browse to the special's own page, then click Edit in Plex, or 'Edit metadata' from the menu in Jellyfin, to make your changes there [**Image D**].

» This is a fiddly approach, however, and your tags are stored by default within the media server's own database, which means you could lose all your carefully curated metadata if anything happened to the server.

7 CONFIGURE METAX FOR TAGGING

The good news is that the MP4 file format allows you to embed metadata and even artwork directly into the file itself. Armed with the right tools, you can incorporate metadata from online databases such as theMovieDB and TheTVDB or populate the tags yourself.



Edit Buffy the Vampire Slayer - Interviews: Joss Whedon and Davi...

Title: Interviews: Joss Whedon and David Boreanaz
Sort Title: Buffy the Vampire Slayer S00E11
Originally Available: 1900-01-01
Content Rating:
Rating:
Summary: Joss Whedon and David Boreanaz are interviewed about the show's first season.

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›› Those tools are MetaX for Windows (costing $9.95 from www.danhinsley.com), and MetaZ for macOS, which is free from https://metaz.maven-group.org/.

›› Both tools work in a similar way, but we'll focus on MetaX. After launching for the first time, click the Settings button to make sure certain features are enabled. First, if you want your MP4 files to be web optimized (in other words, to start streaming before the full file is downloaded) then make sure you check 'Enable Network Streaming' under the File tab.

›› By default, metadata is embedded into the files themselves; Jellyfin users can tick 'Write NFO File' if you'd prefer to store tags separately (they will be saved to the same folder as your MP4 file, so make sure the NFO files go where the files do to preserve the link). Once done, switch to the Data tab to verify which metadata providers are used. TheTVDB and theMovieDB lead the way here, which covers most bases, but iTunes and TVMaze are also available as a fallback. Click OK.

8 DOWNLOAD AND EMBED TAGS

Now click the folder button in the top left and select the files you wish to add to MetaX's queue for tagging and processing. They appear in the right-hand pane, all selected by default, which means any edits apply to all files. You can select a single file to edit, or Ctrl-click to bulk edit a group of files.

›› To embed existing tags from a supported database into one or more files, make sure they're selected. Assuming the files are named correctly, you should see the name of the movie or TV show pasted into the Search box on the left, so click Search!

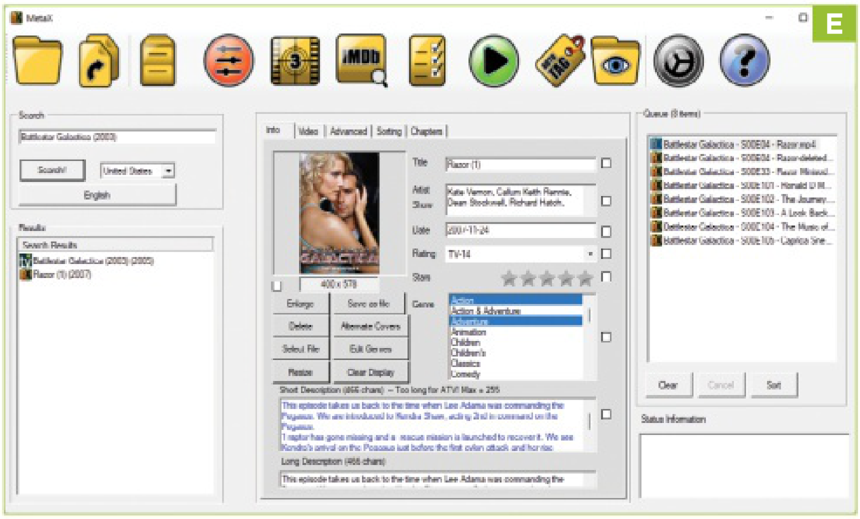
›› A list of matching entries will appear, complete with icons helping you identify which provider they've come from. Select a result and wait a few seconds—you'll see the Info tab in the middle magically fill with metadata (including artwork) from the online database [**Image E**]. Switch to the Video tab where you'll find more information has been pre-filled.

›› Click on a field and make your changes. If you don't like the artwork, right-click it: choose Select File to pick a replacement or Delete to remove it completely. By default, Plex and Jellyfin will pick a thumbnail from the file to display in its place.

›› If you've selected more than one file, then each one will fill with information from the search result. Go through each one to check the details. If correct, click the Play button to process the queue and write the tags (and artwork if applicable) into the file.

9 ADD METADATA MANUALLY

For files where no metadata exists, you can add tags yourself. First, assuming these are all files from the same show, if you select them all, then any tags you enter, such as Show on the Video tab, will apply to all the files simultaneously. Once you've filled in common tags, you can then select each file in turn and enter episode-specific information yourself.


MetaX
Search
Battlestar Galactica (2003)
Search!
United States
English
Results
Search Results
Battlestar Galactica (2003) (2005)
Razor (1) (2007)
Info | Video | Advanced | Sorting | Chapters
Title
Razor (1)
Artist
Show
Date
Rating
TV-14
Stars
Genre
Action
Action & Adventure
Adventure
Animation
Children
Children's
Classics
Comedy
400 x 578
Enlarge
Save as file
Delete
Alternate Covers
Select File
Edit Genres
Resize
Clear Display
Short Description
Long Description
Queue (8 items)
Clear
Cancel
Sort
Status Information

E

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›› MetaX offers a few handy shortcuts: first, the Title field on the Info tab is actually determined by whatever you enter in the Video tab's Episode ID field. Next, information from the filename will be used to pre-populate fields like Episode #, Episode ID, and so on.

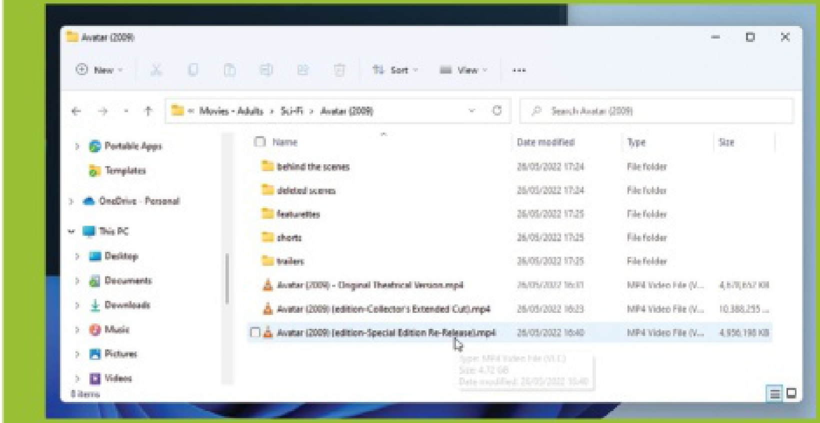
›› You can enter as much or as little information as you like, but make sure all TV Tags (except Description) are filled on the Video tab, verify the Video Kind dropdown is set correctly (TV Show is the default, but Movie and Music Video are options), then switch back to the Info tab to fill in the Long Description field and add artwork.

›› Typing descriptions can be time-consuming, so it's worth seeing if you can find a handy descriptive list of supplements online, such as an online wiki or reviews posted on blu-ray.com and bluray.highdefdigest.com.

›› You might also want to import chapter titles where applicable to the Chapters tab. If the file has an entry under TheTVDB, try clicking the ChapDB button, which may provide these automatically, but you can input them manually or import them from elsewhere too.

›› Again, once you've set up the files as you wish them to appear on your media server, click the play button and wait for the files to be written to disk. ⏻

PLEX MOVIE EDITIONS


Avatar (2009)
New
Sort
View
Movies - Adults › Sci-Fi › Avatar (2009)
Search Avatar (2009)
Portable Apps
Templates
OneDrive - Personal
This PC
Desktop
Documents
Downloads
Music
Pictures
Videos
8 items
Name
Date modified
Type
Size
behind the scenes
deleted scenes
featurettes
shorts
trailers
File folder
Avatar (2009) - Original Theatrical Version.mp4
Avatar (2009) {edition-Collector's Extended Cut}.mp4
Avatar (2009) {edition-Special Edition Re-Release}.mp4
MP4 Video File (V...

While Jellyfin handles multiple movie versions and editions using the same suffix filename style (see step five), Plex is less flexible with this approach. Plex prefers you to use suffixes for multiple versions of the same file only. This means your client either picks the best option based on available bandwidth or lets you choose from a list that only displays each version's resolution and bandwidth.

If you'd like to offer multiple editions of a film, you're advised to try a different naming convention. Although Plex recommends separate directories for each edition, you can store them all in the same directory:

Avatar (2009)
Avatar (2009) {edition-Collector's Extended Cut}.mp4
Avatar (2009) {edition-Special Edition Re-Release}.mp4

If you then want to store multiple versions of each edition, you'll need to adapt the naming convention again:

Avatar (2009).1080p.{edition-Collector's Extended Cut}.mp4
Avatar (2009).SD.{edition-Collector's Extended Cut}.mp4

The result is that each edition is listed separately in your library. You could then consolidate them all into a single collection if you wish. Sadly, the naming convention isn't currently compatible with Jellyfin, which simply lists all three movies as separate entries of the same movie with no specific edition listed for each.

LAB NOTES

GUY COCKER, EDITOR-IN-CHIEF

Death of Stadia

Will game streaming ever take off?

Google Stadia was technically great, but it lacked original content.

IN A MOVE THAT was inevitable but still shocking, Google announced it will close its game streaming service Stadia in January 2023, three years after it launched. The writing was on the wall when the company shut its internal game development studios in early 2021, indicating a lack of interest in creating unique experiences for the system.

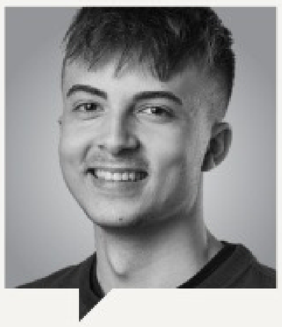
Google's mistake was that it only released five exclusives for the platform. As Nintendo and Sony know, such platforms need a stream of unique, compelling content to succeed—something even Amazon appreciates with its own well-funded if floundering games studios.

The timing was ironic for me. The day before Google's announcement, my LG TV's app store threw up a promo for three months of free Stadia Pro, which I promptly took up. The trial reminded me how good Stadia is, from a technical perspective, with excellent responsiveness, visual fidelity and ease of access, such as the feature to pair a Bluetooth controller via your phone to play on your TV without needing additional hardware. No wonder Ubisoft was keen to use Stadia to power its own cloud offering for Ubisoft+ when Google white-labelled it earlier this year.

But paying $10 per month for Stadia Pro and its 60 games feels far too expensive next to Xbox Game Pass's $15/month for 300+ blockbuster titles, all of which can be streamed online or played locally on an Xbox or PC. Buying new titles, meanwhile, was as expensive as it was on consoles, but you couldn't play them without an internet connection. No wonder people stayed away!

As Microsoft has shown, there's a market for cloud gaming when it's additive, rather than the core of the service. If Amazon can pivot away from its $50 per year Luna subscription and roll it into Prime, it would be unstoppable.

In the meantime, I'll enjoy my last couple of months of Stadia Pro and look forward to the next company to take a crack at cloud gaming. Who knows, given its thirst for new subscribers, maybe Netflix will have a go?



SAM LEWIS

Staff Writer

Are you bored with your TV? Is it time to ditch your conventional display? Well, that's exactly what I've done for the past six months. My visual weapon of choice is now the XGIMI HALO+ and there are a few reasons why I have chosen this little pocket rocket. It's a compact device that has freed up some much-needed room in my office. I still use a monitor for my PC, but when I just want to kick back and relax, using a projector has been a dream. It allowed me to move my TV out and create a minimalist setup.

I've stored this projector on a shelf and as it's Android TV-powered and features Google Chromecast, it sits alone up there. I have had no issues with it either. Sure, the quality isn't as clear as an OLED but I'm mostly using it for YouTube and watching sports, so I don't need the full capacity of an OLED panel anyway.

Using a portable projector also gives me the freedom to adapt my screen size and take it with me when I'm working away. It's slightly larger than the size of an Apple Homepod, so you can easily chuck it in a backpack and away you go. But there is something that a projector offers that a regular TV doesn't. That's a sense of nostalgia, remembering trips to the cinema, and a grainy effect that adds to the experience.

For now, I'm happy to continue consuming media. this way. Who wouldn't want a 150in display in their room?

N
23°
W
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Editor's Pick: Samsung Galaxy Watch5 Pro

Is escaping Apple's ecosystem good for your health?

IN THE WEARABLES market, it seems as though there's the Apple Watch and not much else. Sure, I have sporty, outdoorsy friends who swear by their Garmins, but that's another niche of the watch market that Apple could soon swallow up with its Ultra edition (see our teardown on page 62).

I was an early adopter of the Apple Watch back in 2015, enjoying the ability to pay using my wrist, glance at notifications, and go running without taking my phone. But I've subsequently seen the light and moved over to the Android ecosystem, currently in the form of the Samsung Galaxy S22 Ultra smartphone.

I'd used a couple of Google Wear OS smartwatches before, namely the Skagen Falster 3 and Fossil Gen 6, and found them severely lacking in terms of performance, design, and battery life. They were, however, reasonably priced at less than $200, which is why I'd stayed away from Samsung's more expensive offerings. However, with my tech addiction failing me once again, I decided to take the plunge on Samsung's newest premium watch, which costs $450—although, thankfully, Samsung's generous trade-ins, discounts, and bonuses brought this closer to $250.

The Watch5 Pro is an excellent Android watch that is handsomely designed, packed full of features, and has a battery life of two or three days, which is much better than the previous generation Watch4 Classic. This boost alone means that the watch works well as a sleep tracker—leave it on your wrist when you go to bed and it will monitor your sleep quality and heart rate, while your Samsung watch records your snoring. Scary, but enlightening!

Not all the health features are winners though. You need to be tied into the Samsung ecosystem to get them to work, which is the main reason I left Apple's walled garden in the first place. I couldn't get the blood pressure monitoring to work because my readings were out of range, even though I have no such problems with a Withings monitor. Once I did get it calibrated (by lying), I left it a few weeks before taking another test on the watch, and it said it needed to be calibrated again. It was so frustrating I could feel my blood pressure rising—not the intended effect.

The best thing about the Galaxy Watch5 Pro, though, is that it just works. It has a snappy interface, the apps you want, and lots of options to tailor the watch face to smart, sporty, or fun appearances depending on the occasion. I could download music to the YouTube Music app to listen to on my runs, view and respond to messages quickly and discreetly, and get walking directions on Google Maps without needing to look at my phone. The ability to juice up the watch using reverse charging on a Galaxy phone is also a fantastic touch Apple could learn from.

I'll admit, it's not quite as seamless as an Apple Watch though. I hate that unlocking my phone doesn't also unlock my watch, meaning I have to draw a pattern every time I put the Galaxy Watch on. Samsung also seems hellbent on getting you to use subpar apps like Bixby and Samsung Pay, but it's relatively easy to replace them with Google Assistant and Google Wallet.

I've just had my head turned once again by Google's sleek new Pixel Watch, but for now, I finally have the premium Android wearable I've spent the last few years looking for. **–GC**

$450 (Wi-Fi), $499 (Cellular), www.samsung.com

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Reviewed...

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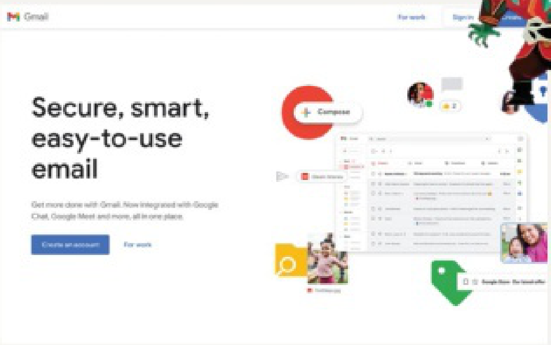
82 HP Spectre x360 16 2-in-1
84 BenQ X3000i
87 NZXT H7

P3 Plus
crucial

88 Crucial P3 Plus 2TB
90 Return To Monkey Island


Secure, smart, easy-to-use email

92 Gmail vs. Outlook

Nvidia's RTX 4090 Founders Edition boosts the fan size and thickness of the chunky old RTX 3090.

GeForce RTX 4090 Founders Edition

A tour de force for Nvidia's Ada Lovelace

EVERY COUPLE OF years, the planets align in such a way that allows for the birth of a new generation of graphics cards. Right on schedule, Nvidia's Ada Lovelace has arrived, and with it the new RTX 4090 Founders Edition. It isn't the biggest 4090 graphics card, that's Gigabyte's 4090 Aorus Master. The RTX 3090 Ti paved the way earlier this year, with a 450W TBP (total board power) and support for the new 12VHPWR 16-pin power connector. The RTX 4090 doesn't increase the power requirements, but performance sees a major jump, potentially the biggest generational boost we've seen for GPUs.

The RTX 4090 has more GPU cores and higher clocks than the outgoing 3090 Ti—we saw clocks of 2.7GHz or more while gaming. It's a theoretical 106 percent improvement in compute performance, but that's only the start. Real-time ray tracing continues to gain steam and Nvidia is betting big on it—the Ada GPUs include multiple enhancements, such as Shader Execution Reordering, Displacement Micro-Meshes, Opacity Micro-Maps, and twice the triangle/ray intersection rate per RT core that substantially boost RT performance (see how on page 32).

Then there's DLSS 3, which requires an Ada GPU. Take DLSS 2's Super Resolution upscaling, then add in a more potent Optical Flow Accelerator (OFA) that can create two frames of content for every one frame the CPU and GPU render. You get up to double the performance of plain old upscaling, and it's hard to spot the differences between rendered frames and generated frames. DLSS 3 impresses on many levels, leaving Nvidia's competitors once more playing catch up. XeSS and FSR are fine, but DLSS 3 takes things to a whole new level. There are presently more than 35 games and game engines planning to adopt the technology, and we expect more to follow.

DLSS 3 benefits CPU-limited games such as *Flight Simulator*. Using a preview build, the RTX 4090 managed 83fps at 4K native, DLSS Quality upscaling didn't help, but Frame Generation overcomes that, spitting out a whopping 160fps. *Cyberpunk 2077* and *A Plague Tale: Requiem* with DLSS 3 also showed impressive gains of around 50 percent versus DLSS 2. With Balanced or Performance upscaling alongside Frame Generation, performance can be two or three times higher than native.

Considering the huge increase in performance, anyone wanting to upgrade to an RTX 4090 will need to make sure the rest of their PC is up to snuff. A fast CPU is a must—such as the Core i9-12900K, the upcoming 13900K, or AMD's new Ryzen 9 7950X. Having a sufficiently large PSU is also important and if you want to avoid the ugly-looking quad-8-pin to 16-pin 'octopus' adapter, find an ATX 3.0 PSU with native 16-pin support.

We suspect the RTX 4090 will reign over this generation of GPUs, though we haven't seen AMD's RDNA 3, due in the next month or two. If you aren't comfortable dropping $1,600–$2,000 on a graphics card, waiting to see how AMD's hand plays out would be sensible. Based on what we know, AMD will have smaller chips and use chiplets, meaning it could seriously undercut Nvidia on pricing.

But if you want the best and have a bulging wallet, Nvidia and the RTX 4090 will happily take your money. Along with extreme performance, you'll get improved features and technology, from a company with enough market share that it can steer graphics APIs almost wherever it wants. And you'll be able to enjoy the fastest and most advanced GPU on the planet... at least until the RTX 4090 Ti drops next year. –**JARRED WALTON**

VERDICT
9
KICK ASS!

GeForce RTX 4090 Founders Edition

➕ **BIG CHUNGUS** Blistering performance; architectural upgrades; DLSS 3.

➖ **JACK SPRAT** Extreme pricing; might need a PSU upgrade; need to see RDNA 3.

$1,599, www.nvidia.com

BENCHMARKS

	RTX 4090	RTX 3090 Ti	RTX 3090	RX 6950 XT
10 Game Average	**143 / 106**	108 / 70	100 / 63	104 / 63
Borderlands 3	**210 / 126**	138 / 80	122 / 70	144 / 78
Control (DXR)	**135 / 67**	79 / 40	70 / 35	53 / 25
Cyberpunk 2077 (DXR)	**86 / 44**	50 / 25	45 / 22	29 / 13
Far Cry 6	**150 / 133**	140 / 91	132 / 84	**150** / 94
Flight Simulator	78 / **78**	**87** / 70	**87** / 64	82 / 55
Forza Horizon 5	**172 / 149**	115 / 88	109 / 82	136 / 98
Horizon Zero Dawn	**176 / 154**	162 / 102	153 / 93	170 / 93
Minecraft (DXR)	**106 / 62**	69 / 35	64 / 32	37 / 18
Red Dead Redemption 2	**179 / 138**	133 / 94	119 / 84	122 / 84
Watch Dogs Legion	**134 / 115**	109 / 71	102 / 65	121 / 69

Best scores are in bold. All testing conducted with a Core i9-12900K, MSI Pro Z690-A WiFi DDR4, 2x16GB DDR4-3600 CL16, 2TB Crucial P5 Plus M.2 SSD, Cooler Master MWE 1250 Gold V2. Scores are average framerates at 2560x1440 / 3840x2160 ultra, with ray tracing enabled in Control, Cyberpunk, and Minecraft.

SPECIFICATIONS

Architecture	AD102
Lithography	TSMC 4N
Boost Clock	2520 MHz
GPU Cores	16384
Memory	24GB GDDR6X
TFLOPS FP32	82.6
Bandwidth	1008 GBps
TBP	450W
Connectors	1x HDMI 2.1, 3x DisplayPort 1.4

AMD RYZEN
AMD Ryzen 9 7950X
100-000000514
BQ 2226PGY
9KN1070S20022
DIFFUSED IN TAIWAN
MADE IN MALAYSIA
© 2021 AMD

Blistering multithreaded performance makes this a content creator's dream

AMD Ryzen 9 7950X

Insane multithreaded performance

SO HERE WE ARE—after months of rumors about AMD's Zen 4 and Intel's Raptor Lake CPUs, both arrive within weeks of each other. We'll have to wait until next month for the arrival of Intel's Core i9-13900K to put it through its paces, but the first top-of-the-line offering from AMD, the Ryzen 9 7950X, is here. Coming in at $699, it's a premium CPU for sure, but at $100 less than the 5950X it effectively replaces, it's also pretty good value for money.

These latest AMD chips require the new AM5 motherboard platform and DDR5 memory, unlike Intel's Raptor Lake series, which can use both new motherboards and DDR5 RAM or older Alder Lake mobos and DDR4 if necessary. Unless you're already using DDR5, that means an AMD upgrade will be the more expensive upgrade path, even if it's faster and better equipped for the future.

Underneath AMD's funky new heat spreader design is a seriously powerful CPU. Despite the new hardware requirements, it's an evolution, not a revolution, building on the existing Zen 3 with a healthy clock speed bump and a liberal approach to thermal limits. On a hardware level, AMD has leaned on foundry partner TSMC to build on a new process node, with the eight-core chiplet (CCD) going from 7nm to 5nm lithography, while the I/O die (IOD) has shifted from 12nm to a 6nm node, creating a more efficient chip overall.

The most noticeable change for consumers will be at a hardware level. Aside from DDR5 memory, there's also PCIe 5.0 support for future storage and graphics options which, while there are no compatible products right now, gives Zen 4 an excellent level of future-proofing.

Another notable platform upgrade is Hybrid Graphics. This chip features a pair of RDNA 2 compute units to allow for basic graphics applications for those without a discrete GPU. But if you do have a graphics card, you can just plug your monitor into the video output from the motherboard, and the system will intelligently decide when to use the CPU's integrated graphics or the beefier GPU, just like a laptop. The downside is that there's a 3-5 percent performance impact in the best-case scenario and a 10 percent hit at worst, something PC gamers may not be able to stomach, even for convenience and power savings.

The chip's multithreaded performance is astounding, but single-thread and gaming performance disappoint. As the benchmark table below shows, the AMD chip is unbeatable right now in Cinebench Multi-Thread and Blender performance tests but, sadly, falls behind Intel's 12900K in everything else.

AMD's cores were capable of tipping over 5.9GHz in our tests, which is blazingly fast out of the box. We mean that literally—AMD intentionally allows its chip to go up to 95 degrees under load as it's the ideal way to squeeze maximum performance out without damaging it. For creators, the benchmarks are astonishing, with multithread Cinebench R23 performance 54 percent better than AMD's previous chip and 38 percent faster than the 12900K.

In gaming, there's a minor improvement over the Ryzen 9 5950X and Ryzen 7 5800X3D, while Intel's Core i9-12900K was still faster than all of AMD's chips for gaming. With that chip's Raptor Lake replacement imminent and a presumed further performance increase, it's hard to recommend AMD's offering to gamers.

We find ourselves in a state of flux in the CPU market, with multiple new chips coming through at the high- and mid-end that use new technologies, some of which aren't yet available. Right now, AMD's Ryzen 9 7950X is the best chip out for demanding content creators, but that could change once we test Intel's equivalent offering. This is a great chip, but we'd wait to see what Intel has in store before upgrading. **–GUY COCKER**

VERDICT
8

AMD Ryzen 9 7950X

+ MULTITHREADED MASTER $100 less than 5950X; brilliant multithreading; 5.9GHz(!).

− MULTITHREADED MADNESS Beaten in games by previous-gen chips; X3D gaming chip due Q1 2023; requires new motherboard and RAM.

$699, www.amd.com

BENCHMARKS

	AMD Ryzen 9 7950X	AMD Ryzen 9 5950X	Intel Core i9-12900K
Cinebench R23 Single (Index)	1,934	1,617	**1,960**
Cinebench R23 Multi (Index)	**37,112**	24,109	26,988
PCMark 10 Express (Productivity Benchmark)	6,831	6,242	**6,909**
Blender 3.3.0 (Samples per minute)	**174.6**	124.1	115.2
Metro Exodus (DX12, Ultra, 1080p)	126	121	**133**
Shadow of the Tomb Raider (DX12, Highest, 1080p)	216	181	**217**
Total War: Three Kingdoms (DX11, High, 1080p)	204	196	**213**
3DMark Time Spy (1440p)	16,980	16,246	**17,660**

Best scores in bold. AMD test bed consists of an ASRock X670E Taichi motherboard and G.Skill Trident Z5 Neo DDR5-6000 CL30 2x 16GB RAM, while Intel test bed features an Asus ROG Z690 Hero motherboard and G.Skill Trident Z5 RGB DDR5-5600 CL36 2x 16GB RAM. Both systems used an Nvidia RTX 3080 10GB, 1TB WD Black SN850 SSD, Corsair H100i RGB cooler and NZXT 850W PSU.

SPECIFICATIONS

Cores	16
Threads	32
Socket	AMD AM5
CCD lithography	TSMC 5nm
CCD die size	70mm^2
CCD transistor count	6.5 billion
IOD lithography	TSMC 6nm
IOD die size	122mm^2
IOD transistor count	3.4 billion
Max boost clock	5.7GHz
Base clock	4.5GHz
L2 cache	16MB
L3 cache	64MB
Memory support	DDR5-5200 (non-OC)
TDP	170W

Intel Arc A770 Limited Edition

Player 3 has joined the game

AS IMPRESSIVE AS Nvidia's RTX 4090 is when it comes to raw performance, the Intel Arc A770 may even be more surprising in many ways. After the disappointing A380 (see November issue), its bigger sibling the A770 delivers a compelling set of performance and features at an aggressive price. There are some growing pains with Intel's graphics ambitions, such as the drivers that may not always work correctly and will likely leave some untapped performance on the table. But Arc is here and it's mostly good.

Intel took a long, hard look at Nvidia and appears to have told its engineers to match or exceed the RTX cards on every major feature. Along with the expected GPU cores, the Alchemist architecture packs XMX cores (the equivalent of Nvidia's Tensor cores) and Ray Tracing Units (RTUs) that square off against Nvidia's RT cores. DLSS also gets an AI-powered upscaling solution with XeSS. Intel hasn't gone after the pinnacle of the GPU hierarchy, but instead is looking to carve out a slice of the mid-range pie.

The A770 Limited Edition matches street pricing on the RTX 3060, and you get 16GB of GDDR6 memory with a 256-bit interface, instead of 12GB and a 192-bit interface. Intel's memory is clocked higher as well, at 17.5Gbps. The resulting performance pretty much sweeps the RTX 3060 aside, and also beats AMD's RX 6650 XT.

Intel's Arc beats the 3060 in traditional rasterization by around 15 percent on average, and slightly leads the 6650 as well—it's a touch slower at 1080p but comes out ahead at 1440p. And while we're used to seeing excuses for AMD's ray-tracing performance, the A770 is having none of that. It matches or leads the RTX 3060 in our two DXR games, and the same gap exists across several other ray-tracing games that we've tested.

But Arc doesn't walk away with a clear win, as we ran into a few issues with the drivers. Some had workarounds, others required an update from Intel, and at least one game in our test suite—*Minecraft* with ray tracing enabled—wouldn't let us turn on ray tracing. That's the developers' fault, as the game has a whitelist of hardware it recognizes, but it surely won't be the only such example.

There are still occasional performance hiccups (*Horizon Zero Dawn* at 1080p), but there are also standouts, such as *Red Dead Redemption 2* where the A770 is head and shoulders above the competition. If it performed that well in every game, even the RTX 3060 Ti and RX 6700 XT might be worried. Given time and continued driver improvements, Intel might get there, but we wouldn't buy Arc expecting such gains.

Intel's QuickSync and AV1 encoding are also great, and XeSS does okay as a DLSS alternative. Getting developers to support it will be an uphill battle, but there are at least 21 games already on the XeSS list, with more to come. Power use on the other hand isn't so great. The A770 makes full use of its 225W TBP, compared to the 3060's 170W and the 6650's 180W. And it's using TSMC's superior N6 process node where Nvidia's 3060 uses Samsung's 8N.

This isn't the first time Intel has attempted to make a dedicated GPU, but it's far better than the i740 back in 1998 or the aborted Larrabee of 2010. And make no mistake, Intel needs a good GPU program if it wants to compete in the HPC market—which is how Arc came to be, forking off the Xe-HPC architecture and adding ray-tracing elements.

Alchemist was supposed to be out in late 2021 but encountered various delays. Now, it's finally out of the door, the driver issues are being addressed, and Intel is now moving forward with Battlemage. Hopefully, that will arrive sooner rather than later, because Intel is going to need a lot more than just the A770 to compete with future Ada Lovelace and RDNA 3 GPUs. –**JARRED WALTON**

BENCHMARKS

	Arc A770	RTX 3060	RX 6650 XT
9 Game Average	**84 / 64**	73 / 54	80 / 57
Borderlands 3	**94 / 67**	73 / 52	**103 / 67**
Control (DXR)	**86 / 57**	75 / 46	59 / 37
Cyberpunk 2077 (DXR)	**50 / 30**	35 / **30**	23 / 18
Far Cry 6	104 / 81	97 / 71	**119 / 82**
Flight Simulator	**72 / 51**	69 / 49	67 / 46
Forza Horizon 5	86 / **74**	72 / 61	**88** / 69
Horizon Zero Dawn	93 / **83**	100 / 78	**115 / 83**
Red Dead Redemption 2	**93 / 74**	69 / 56	72 / 59
Watch Dogs Legion	**78 / 60**	64 / 48	74 / 53

Best scores are in bold. All testing conducted with a Core i9-12900K, MSI Pro Z690-A WiFi DDR4, 2x16GB DDR4-3600 CL16, 2TB Crucial P5 Plus M.2 SSD, Cooler Master MWE 1250 Gold V2. Scores are average framerates at 1920x1080 / 2560x1440 ultra, or 1920x1080 medium / ultra with ray tracing enabled in Control and Cyberpunk.

VERDICT
7

Intel Arc A770 Limited Edition

+ **NOAH'S ARK** Solid architecture; 16GB; good value; more competition.

− **ATLANTIS** Driver concerns; not particularly efficient; delayed launch

$349, www.intel.com

SPECIFICATIONS

Architecture	ACM-G10
Lithography	TSMC N6
Boost clock	2100MHz
GPU cores	4096
Memory	16GB GDDR6
TFLOPS FP32	17.2
Bandwidth	560GB/s
TBP	225W
Connectors	HDMI 2.0b, 3x DisplayPort 2.0 10G

Intel will sell Arc GPUs under its own Limited Edition, which will not actually be limited in any way and comes packing 16GB of VRAM plus lots of RGB.

Lenovo Legion Y25-30

This gaming panel is a nifty little number

IN THIS CRAZY old world of almost infinite consumer choice, PC gamers are faced with a few trade-offs when selecting an affordable screen, which is where the Lenovo Legion Y25-30 comes in. At 25 inches and just 1080p native resolution, it's modestly specified. What you get is a maximum refresh rate of 280Hz via an IPS panel that's claimed to be good for 0.5ms response. And all for $340.

The Y25-30 prioritizes speed, but that's not all it has going for it. The panel is an eight-bit IPS model with HDR400 support and 400 nits of brightness. There's good connectivity too, with DisplayPort, HDMI, and a quad-port USB hub. USB-C doesn't feature—the benefit would be single-cable connectivity with power delivery. But the 100W maximum power provided by the existing USB-C spec isn't good enough for a proper gaming laptop.

The fully adjustable stand is a definite plus with height, tilt, swivel, and even rotate into portrait on offer. Styling-wise, there are slim bezels on three sides of the panel and a few design flourishes that lift the Y25-30 above the usual fare. You wouldn't choose this monitor for pure build quality though, as it's too plasticky.

Out of the box, the Lenovo Legion Y25-30 makes a decent first impression. At maximum brightness, it's fairly punchy and the colors are vibrant. Strictly speaking, the whites aren't quite as clean as we'd like. There's a slight yellow tinge that can't be entirely calibrated out, but it's barely noticeable and with extended use, it probably wouldn't register at all.

Probably the weakest aspect in terms of static image quality is contrast. Rated at 1,000:1, there's a fair bit of light bleed, which is to be expected from an IPS panel with no local dimming. A little of the typical IPS glow is visible as you move your head around. It goes with the territory and means it's not a true HDR panel, never mind the HDR400 certification.

Still, it's motion that really matters for this monitor and also where it definitely delivers. Lenovo has fitted out the Legion Y25-30 with four levels of conventional pixel overdrive, plus an MPRT mode. The conventional options top out at a claimed 1ms and even on the fastest setting, there's almost no visible overshoot or inverse ghosting. If the bit that is apparent bothers you, the option to fall back one notch to the 2ms is there.

As for the MPRT setting, predictably it comes at the cost of brightness. Our pick would be one of the two faster conventional overdrive modes, either of which delivers a genuinely excellent response. In subjective terms, you'd have to go to an OLED panel to get a better experience in terms of pixel speed. This thing is properly quick.

Likewise, the 280Hz refresh serves up silky smooth performance in any game where high frame rates are on offer—provided you have a graphics card powerful enough, of course. That said, the modest 1080p resolution is all about allowing higher frame rates without crushing your GPU. So you don't need to purchase a $1,000 board to get the best out of this monitor. It's a great match with mid-range graphic cards such as an Nvidia GeForce RTX 3060.

All of which means that we've little to complain about. A high-refresh 1080p screen isn't really our bag though. We'd prefer to compromise on the Hz and add more pixels with something like a 144Hz 1440p panel. But if high frame rates and excellent response are your priorities, put the Y25-30 on your shortlist. It's a great little gaming panel. **–JEREMY LAIRD**

VERDICT

8

Lenovo Legion Y25-30

➕ **SPEED DEMON** Seriously quick IPS panel; quick 280Hz refresh.

➖ **WHAT THE HELL?** Only 1080p native resolution; not a true HDR panel.

$340, www.lenovo.com

SPECIFICATIONS

Screen size	24.5-inch
Panel type	IPS
Resolution	1,920 x 1,080
Brightness	400 nits
Contrast	1,000:1
Response time	0.5ms (MPRT)
Refresh rate	280Hz
Color coverage	99% sRGB
HDR support	DisplayHDR 400
Adaptive sync	FreeSync Premium
Connectivity	DisplayPort 1.2, HDMI 2.0, USB-A hub

© UNSPLASH

At 1080p, the Lenovo Legion Y25-30 is a little short on pixels but it packs plenty of speed.

HP Spectre x360 16 2-in-1

An outstanding OLED-powered, 16-inch all-rounder

A SINGLE LAPTOP for almost every occasion? That might just be the new HP Spectre x360 16 2-in-1. This 16-inch laptop is pretty loaded. How so? It starts with a 16-inch OLED screen with a beyond-4K native resolution. There's a 12th-gen Intel processor, two-in-one tablet functionality, and 1TB of SSD storage. And did we mention Intel's controversial new Arc graphics chip? But that's just the obvious stuff. The finer details include an HP input pen, speakers by Bang & Olufsen, a fingerprint reader, a digital creativity software bundle, a 5MP webcam, and a hefty battery with a claimed life of up to 15 hours.

It's all wrapped up in a sleek, slim, and moderately portable all-alloy chassis and offered at a remarkably reasonable price. It's a decent proposition on paper and in practice, it's pretty sweet, too. The chassis sports the HP Spectre range's signature crisp lines and excellent build quality, including a nice, solid keyboard bed and robust hinges for the 180° trick when converting into tablet mode. All in, the Spectre weighs 2kg, which isn't exactly featherweight. You wouldn't want to hold it and use it as a tablet for long, but it's pretty portable for this class of laptop.

That said, the Spectre's design can't compete with the likes of Dell's zero-bezel XPS laptops for visual delight. The thicker bezels and slightly dated look don't have the same showbiz sizzle as the ultra-modern XPS family. Connectivity is decent, however, courtesy of a pair of full 40Gbps USB4 ports with Thunderbolt, and a clever hinged USB-A port with 10Gbps throughput that allows for the slim chassis. You also get a full-size HDMI socket in 2.1 spec with high-refresh 4K output capability. A microSD slot rounds out a reasonable selection of ports.

But what about the performance? Doing processing duty is an Intel Core i7-1260P chip with four performance cores and eight efficiency cores. For graphics, it's that fancy new Intel Arc A370M mobile GPU. As discrete graphics chips go, it's admittedly very much entry-level, but still a welcome alternative to the usual Nvidia and AMD options.

Backed up by 16GB of DDR5 memory, the CPU and GPU deliver a solid core performance. While you wouldn't want to use this as, say, a dedicated encoding rig, there's decent performance on tap for getting moderate content creation workflows done. Our main reservation involves HP's factory software configuration. It's hard to be sure exactly what is causing the problem, it may be related to the default McAfee anti-virus software installation. But as with another HP laptop we've sampled recently, last month's HP Elite Dragonfly G3, this Spectre can be a little sluggish when installing software and during some other data-intensive activities.

More unambiguously successful is the OLED screen. It's an absolute beauty, razor-sharp and delivering oodles of contrast and gorgeous colors, not to mention a seriously zingy response. It really does make conventional LCD panels seem antediluvian. If there is a downside, it's that the panel's 60Hz refresh isn't absolutely ideal for digital inking support in terms of input latency. We also felt the screen's sensitivity was a little lacking, especially with lighter input pressures, but the overall inking experience with the bundled MPP2.0-compatible pen is nice enough.

Battery life is another clear positive. This is a 16-inch laptop that can loop 1080p video for 12 hours. In other words, genuine all-day battery life is on offer provided you don't go crazy with really CPU or GPU-intensive tasks. On a final note, the Bang & Olufsen-branded audio is a disappointment. The volume levels are OK but the sound quality is so muddy and flat that it's unpleasant to use the integrated speakers for any significant length of time. It's annoying, but it doesn't prevent the HP Spectre x360 16 2-in-1 from being a super all-round laptop for the money. **–JEREMY LAIRD**

VERDICT

8

HP Spectre x360 16 2-in-1

+ **TOUCH OF CLASS** Stellar OLED screen; nice build quality; great battery life.

− **BROKEN GLASS** Awful sound quality; questionable default software config.

$1,500 (estimated), www.hp.com

SPECIFICATIONS

CPU	Intel Core i7-1260P
Graphics	Intel Arc A370M
RAM	16GB DDR5
Screen	16-inch, 3,840 x 2,400, OLED
Storage	1TB, PCIe Gen 3
Ports	2x USB4 / Thunderbolt 40Gbps, USB-A 10Gbps, headphone, HDMI 2.1. microSD
Connectivity	WiFi 6E AX211 (2x2), Bluetooth 5.2
Camera	5MP webcam
Battery	83WHr
Weight	2kg (4.4lb)
Size	10 x 14 x 0.8-inch 254 x 355.6 x 20.32mm

© UNSPLASH

HP's new 16-inch 2-in-1 has a little bit of everything and a lot of OLED-powered visual thrills.

BenQ
4K Entertainment Gaming Projector

BenQ X3000i

Game big or go home?

WHAT DO YOU GET when you cross a highly respected company that specializes in display technology with a quirky piece of tech that significantly differs from the traditional monitor? That's right, you get a projector from BenQ. Given their size and vastly improved quality, projectors now bring a whole new level of immersion to whatever type of media you consume, including gaming, and that's what BenQ has aimed to achieve with the X3000i. This 'gaming' projector should tick all the same boxes as a regular projector, but also double up as an immersive display for your gaming needs.

Before we dive into the quality of the display, let's take a look at the physical aspects offered here. The X3000i doesn't follow the typical design cues of a regular projector, instead, it looks more like a quartz block you'd find in *Minecraft*, albeit a little more interesting. The design features a white, orange, and black color scheme that we like very much. Along the front, there's a black geometric pattern that gives the unit some character, while on the sides, the air inlet and outlet grilles fit seamlessly into the overall aesthetic.

The lens sits on the top left as you look toward the projector. With a maximum output of up to 3,000 lumens, this lens is bright, so don't make the same mistake we did and look directly at it while it's switched on. The good thing about having the lens in this position is that you can physically adjust the focus and zoom from the side of the projector. Although on other projectors you can do this via software, manually adjusting the dials is still the best way for precision.

Next to the zoom and focus dials, you'll find a control panel, containing buttons for the power, input source, back, menu, eco blank (blanks the screen), directional arrows, plus an OK button. There is also a remote control for the Android TV element of this projector. Talking of which, this dongle connects underneath the projector and is powered by a USB cable. This is needed to replace your television, so we were glad to see that it's been included in the package.

Connectivity is decent, including the Android TV dongle, and around the back there are a reasonable amount of ports. There are two HDMI inouts, a 12V DC output, SPDIF audio output port, an RS-232 control port, a 3.5mm audio output jack, and a USB 2.0 Type-A port. It would have been nice to see DisplayPort or USB-C inputs but, alas, they aren't here.

Also at the back are the BenQ treVolo speakers. With a few menu tweaks and EQ choices (preferably using the Cinema setup), the sound is decent through these integrated speakers. However, we would recommend hooking it up to a separate sound system, especially if you're thinking of setting up a cinema room.

Now let's talk about the way the X3000i shines. As we mentioned earlier, it's extremely bright and, at 3000 lumens, this can easily light up a room, pumping out a brilliant image. Even in its standard settings, when you first boot up the X3000i and expand the image of your PC or console across your wall, it's highly impressive out of the box. In all of its 4K glory, the color accuracy looks incredible for a projected display.

Boasting 100 percent DCI-P3 color coverage, the X3000i produces a stunningly rich image with a vast color range. Quality is super-sharp with a strong contrast making it perfect for kicking back and watching a film. You'll also be pleased to hear that it's ideal for gaming and we lost many hours testing the projector out with a variety of games. To get the best performance, we had to change the resolution down to 1080p but this allows for the maximum 240Hz refresh rate to be used.

Playing open-world games such as *Red Dead Redemption 2* or *Cyberpunk 2077* on this projector, with the screen filling up most of the wall we were directing it at, only increases the immersive experience and takes gaming to another level. In fact, we can safely say it's one of the best ways to take a more leisurely stroll through open-world games.

Although the projector has a relatively fast 4.16ms input delay (1080p @240Hz), it isn't quite enough to cope with any fast-paced competitive gaming. If that's not important to you, then the X3000i works fantastically as a general media display upon which to play your favorite games.

With a strikingly good color range, crystal clear 4K resolution, and plenty of connectivity with the Android TV dongle included, it's well worth considering as a TV replacement. **–SAM LEWIS**

VERDICT
9

BenQ X3000i

+ CINEMA MAGIC 4K gloriousness; precise color accuracy; 120Hz gaming; Android TV dongle included.

− BOGUS CINEMATICS 120Hz only at 1080p; boxy footprint; no DisplayPort or USB C connectivity.

$1,999, www.benq.com

SPECIFICATIONS

Projector type	DLP
Light source	4LED
Native resolution	4K UHD 3840×2160
Refresh rate	240Hz @1080p, 60Hz @4K
Brightness	3000 Lumens
Accessories	Android TV Dongle
Projection size	100 inches @8.3 ft
Ports	3X HDMI 2.0, USB 2.0 Type-A, 3.5mm aux, SPDIF audio output, RS-232 control port, 12V DC output.
Weight	14.1lbs
Size	7.8 x 10.2 x 10.7-inches

The BenQ X3000i makes for an immersive gaming experience.

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NZXT H7

Sleek and stylish, but is it the best?

THE NZXT H7 SERIES is sleek and stylish. It's also smart and sophisticated. That's quite a lot of compliments this early on in the review, but the standard edition H7 chassis is all of those things. NZXT knows how to put a case together, but how does this H7 stand within the series, when placed against the Elite and Flow versions we reviewed in our October and November issues respectively? Should your hard-earned cash be spent on the standard H7 or should it go elsewhere?

This is the base model within NZXT's H7 series mid-tower case lineup. Don't let its position at the bottom of the hierarchy throw you off though, as this is a more than capable case. Visually, it is clean and minimal, especially in our all-white review sample. The H7 also comes in an all-black scheme or a mixed black-and-white design. It features subtle gloss-finished logos, one at the bottom of the case and one in the interior, which continue the minimalist look.

On the top of the case, there's a perforated grille to allow airflow either in or out, which is similar to the front of the H7 Flow. The standard H7 case, however, is closer to that of the Elite version than the Flow. Both feature front panels, which aren't great for airflow due to their design. A small air vent on the side is all you'll get in terms of induction from the front fans in this chassis. Talking of cooling, two 120mm Quiet Airflow fans are included. Fan compatibility on the whole in this case is good. At the front, you can install three 120mm or three 140mm fans. You can also fit either three 120mm fans at the top or two 140mm fans. Lastly, at the back, there is room for either a 120mm or 140mm fan. That's encouraging and, regardless of the lack of airflow from the front, if you pack this chassis full of fans, you'll be able to achieve a good level of cooling here.

As this is a mid-tower case, it has plenty of room inside to build with a healthy selection of either a Mini-ITX, Micro-ATX, ATX, or EATX motherboard (up to 272mm). GPU clearance again is decent, allowing you to fit a card up to 400mm in size. The same goes for its radiator clearance. At the front and top you can fit up to a 360mm radiator and on the back, there's space for a 140mm rad.

So this case allows for a whole range of different builds of all shapes and sizes. It also offers two USB 3.2 gen 1 Type-A ports, a USB 3.2 gen 2 Type-C, and a 3.5mm audio jack port. Again, that's a good choice of front I/O panel ports and, on paper, the H7 offers exactly what you need from a case, especially when you consider the clean canvas design. Yet, that's not quite the full picture. This case costs $130 and, for the same price you can get NZXT's H7 Flow chassis instead. In our opinion, that's a better choice as it offers all the benefits of the standard H7 just with better airflow.

On the face of it, there's nothing revolutionary going on here. The H7 is a good case, but the problem is its pricing. If NZXT had sold the standard H7 lower than the better-performing Flow variant, it would have made a lot more sense. Performance and cooling might not be the most important thing for you and, if that's the case, then go ahead and get this case. It's minimalistic, has a high build quality, is compatible, and should last a long time.

For us though, it's just slightly overpriced. The Flow is the best of the three models, offering better value for money than the H7, whereas the Elite is a more premium option. That's not to say the H7 doesn't deserve a place in this lineup, it's just that at this price, it's overshadowed by its siblings. –SAM LEWIS

VERDICT **7**

NZXT H7

+ MASTERFULLY MINIMAL Cleanest design of the bunch; great compatibility; solid build quality.

− PAID THE PRICE Too expensive in this lineup; restricted airflow.

$130, www.nzxt.com

SPECIFICATIONS

Form factor	Mid-tower
Motherboard support	Mini-ITX, Micro-ATX, ATX, and EATX (Up to 272mm)
Colors available	Matte Black, Matte White, White & Black
Window available	Tempered glass
Front I/O ports	USB 3.2 Gen 1 Type-A x2, USB 3.2 Gen 2 Type-C, 3.5mm headset audio jack
Radiator support	Front up to 360mm Top up to 360mm Rear up to 140mm
Fan support	Front 3x 120mm/3x 140mm; Top 3x 120mm/2x 140mm; Rear 120mm/140mm
Graphics card clearance	400mm
Dimensions	19.8 x 18.9 x 9-inches
Weight	22.61lbs

P3 Plus
PCIe® 4.0 M.2 2280
crucial
by Micron

The new Crucial P3 Plus M.2 SSD uses QLC flash memory and a cheap controller chip to keep costs down.

Crucial P3 Plus 2TB

More capacity. Less cash. But is there a hidden cost?

QLC DRIVES ARE all about giving you more capacity for less cash. But the real question is at what cost? Enter the new P3 Plus, Crucial's latest value-orientated M.2 SSD, all 2TB of it in this case, for the not all that princely sum of $179. It's a big old drive for the money.

Apart from the use of cheap QLC rather than faster and more expensive TLC flash memory chips, the P3 Plus exhibits some other pretty obvious corner-cutting. Unlike Crucial's premium SSDs, which are specced out with the brand's own controller chips, the P3 Plus makes do with a bought-in Phison E21T controller. It's basically a budget PCIe Gen 4 chip with four memory channels where premium controllers have eight channels. What's more, it's a so-called DRAM-less controller, meaning it doesn't support dedicated DDR cache memory. In lieu, your PC's system memory handles the primary storage caching.

It's not all bad news, of course. Micron claims its latest 176-layer QLC memory is 25 percent faster than its existing 128-layer QLC chips. The net result is that this 2TB model is good for 5,000MB/s reads and 4,200MB/s writes—that's a fair old way off the fastest Gen 4 PCIe 4 drives. Moreover, Crucial doesn't even bother quoting IOPS performance for the PC Plus. However, that peak sequential throughput is still multiple gigabytes per second. Isn't that plenty?

The drive also comes with Crucial's five-year warranty and 440TB of write endurance. OK, that's only about a third of what you'd get from a premium TLC-based SSD, such as the WD Black SN850. But it still adds up to nearly 250GB of writes every single day for five years. Not many PC users need more than that.

That said, it's worth remembering that the peak performance of pretty much any SSD is contingent upon using a chunk of the drive in high-speed SLC mode. The bigger the drive, the more viable that is, which is why QLC drives make more sense in large capacities like 2TB. Our testing indicates the P3 Plus allocates roughly 500GB of space to high-speed SLC mode when the drive is empty. As you use the drive and fill it up, that figure will shrink. But even half full, you should be able to shunt a couple of hundred gigabytes of data around without exposing the underlying performance of the QLC flash.

That's important, because when the SLC cache runs out, performance crashes, down as low as 90MB/s. However, with the SLC cache in full flow, you can expect to see a performance in line with Crucial peak throughout claims. As for 4K random access, the Crucial P3 Plus isn't actually too shabby, with 263MB/s 4K writes and 63MB/s reads.

The more comprehensive test of drive performance that is PCMark 10 Storage throws up an obvious deficit compared with premium TLC-based drives. The P3 Plus's total score of below 2,500 points is a long way off the 3,500-plus of premium SSDs. Similarly, clocking up 68ms of latency versus something like the mid-40s you'd expect from a TLC drive is surely indicative of the impact of both the QLC flash memory and the cheap controller chip.

Ultimately, then, the Crucial P3 Plus largely does what you'd expect it to. As long as the SLC cache hasn't run out, it should be quick enough for most needs. Likewise, long-term endurance isn't a major worry. The snag is that surely the point of a big old SSD like this is to cram it full of data, a large game library, and loads of media files. You could then find the SLC cache provisioning shrinking to problematic proportions. And in turn, you may wish you'd spent an extra 30 bucks on the P3 Plus's TLC-based 2TB sibling, the P5 Plus. Honestly, that's where our money would go. **–JEREMY LAIRD**

BENCHMARKS

	Crucial P3 Plus 2TB (QLC)	Sabrent Rocket Q4 4TB (QLC)	Seagate Firecuda 530 2TB (TLC)	SK Hynix Platinum P41 2TB (TLC)
Synthetic performance: ATTO Disk Benchmark Peak Sequential Read (MB/s)	6,890	5,333	**6,940**	6,890
Synthetic performance: ATTO Disk Benchmark Peak Sequential Write (MB/s)	5,940	3,317	**6,410**	6,340
PCMark10 Storage (full) Index	2,497	1,482	3,021	**3,477**
PCMark10 Storage (full) Bandwidth (MB/s)	404	243	487	**542**
Average Access Time (μs)	68	116	56	**47**
Peak Temp Temperature (°C)	56	59	**41**	71
CrystalDiskMark 7.0.0 SEQ1M Q8T1 Read (MB/s)	4,985	4,924	7,334	**7,375**
CrystalDiskMark 7.0.0 SEQ1M Q8T1 Write (MB/s)	4,342	3,503	**6,874**	6,872
CrystalDiskMark 7.0.0 RND4k Q1T1 Read (MB/s)	63	65	**83**	**83**
CrystalDiskMark 7.0.0 RND4K Q1T1 Write (MB/s)	263	240	251	**255**

Best scores are in bold. AMD Ryzen 3800X, 16GB RAM, Nvidia GTX 1070, Asrock B550 Taichi

VERDICT

6

Crucial P3 Plus 2TB

+ BIG LOVE Big, cheap and fast enough most of the time; five-year warranty.

− NEEDS TLC Not really cheap enough; underlying QLC performance is feeble.

$179, www.crucial.com

SPECIFICATIONS

Interface	NVMe (PCIe Gen 4 x4)
Capacity	2TB (500GB, 1TB, 4TB also available)
Form factor	M.2 (2280)
Sequential read	5000MB/s
Sequential write	4200MB/s
Endurance	440 Terabytes
Warranty	Limited five-year

Guybrush Threepwood and his nemesis LeChuck are back.

ADVENTURE GAME

Return to Monkey Island

Deep in the Caribbean, there's a three-headed monkey

SPOILER ALERT! The ending of 1991's *Monkey Island 2* was somewhat controversial, as we're sure you recall. Protagonist Guybrush Threepwood, mighty pirate and master of insult sword fighting, and his nemesis the ghost pirate LeChuck were revealed to be brothers playing in the maintenance area of an amusement park, told to clear out by a workman and running out to meet their parents. The whale thing had been in their imagination all along.

This reveal didn't stop the *Monkey Island* series from expanding to five games, though creator Ron Gilbert ceased being involved after the first two, but did leave a convenient jumping-off point for another sequel. *Return to Monkey Island* is that game and Gilbert is back at the helm. It begins with young Guybrush and Chuckie exploring the park, running races and sword fighting, before running into their father, somehow an adult Guybrush Threepwood, who tells a tale of piratical adventures. And now you're up to date.

With the 30-year time jump comes a new art style, plenty of *Star Wars* references (the rights to *Monkey Island* are owned by Disney), and the same old starting location, Lookout Point on Melee Island. This turns out to be a statement of intent, as *Return* covers plenty of old ground, updating the locations with a wink to the camera—having destroyed the fourth wall back in the first game—and some respectful wallowing in nostalgia. Dial-a-Pirate copy protection may be a thing of the past, but pirate-themed point 'n' clicks definitely aren't, and you can still ask a pirate about *Loom*.

This is a spiritual successor in that it's full of ghosts, the earlier games weighing heavily as it tries to burst out in new directions. The Melee Island map retains similarities with the past titles, so if you've played one recently you'll know exactly how to get to the governor's mansion, while using the returning trope of a map puzzle to guide you to new areas.

What's fresh is an acknowledgment that *Monkey Island* fans may be older and have less time on their hands these days, in the form of an extra difficulty setting that has fewer and easier puzzles. Whichever you choose, holding Tab highlights all interactive items on the screen, so there's no more pixel-by-pixel inspection of a scene looking for something you've missed. Before you begin, there's a scrapbook that summarizes the events of the earlier games, so you can catch up on what you already knew or learn it afresh.

Then there's the way the actual pointing and clicking takes place. Sweep the pointer around a location and you now get drop-down labels describing what you might do with an object, with different actions for left- and right-clicks, which change depending on whether you've clicked them already. And as the locations are rich in interactivity, you can spend some time working your way around, enjoying the voice snippets that have been prepared for each and every one of them.

And while there are plenty of nods to the past, you don't necessarily have to have played the five previous games to understand it. There are plenty of new features too, such as an ice prison, a whole island full of limes, and a completely fresh cast of pirates.

'Rich' is a good word to describe *Return to Monkey Island*. It's bulging, dripping, almost fit to burst with things to do and look at. And if, as is the way with most point 'n' clickers, what you're doing boils down to fetch quests and discovering the right combination of objects to use together, that doesn't really matter when it's presented as amiably as this.

There's a hint book if you get stuck, a log so you don't forget what you're doing, and you can scroll back through

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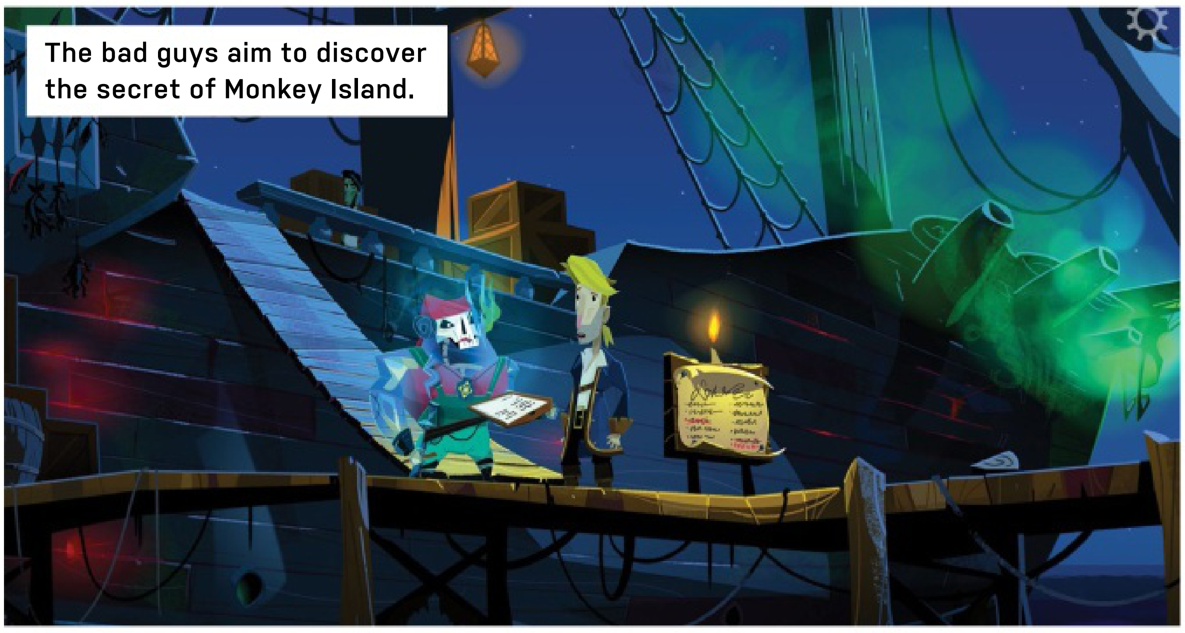
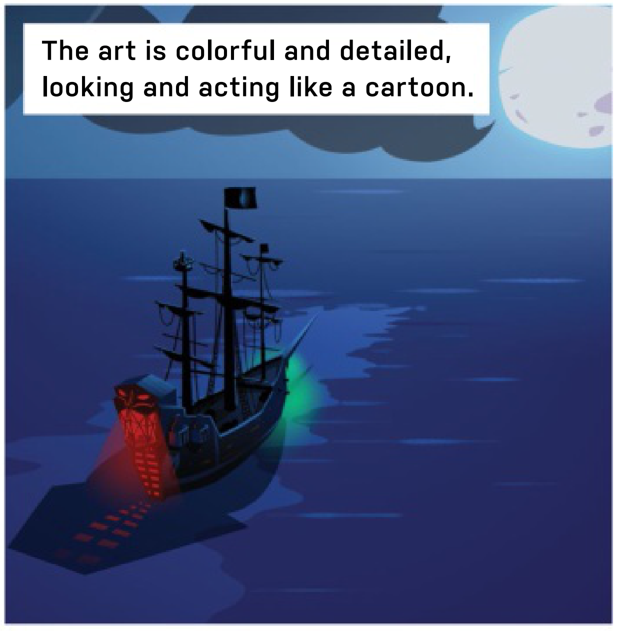
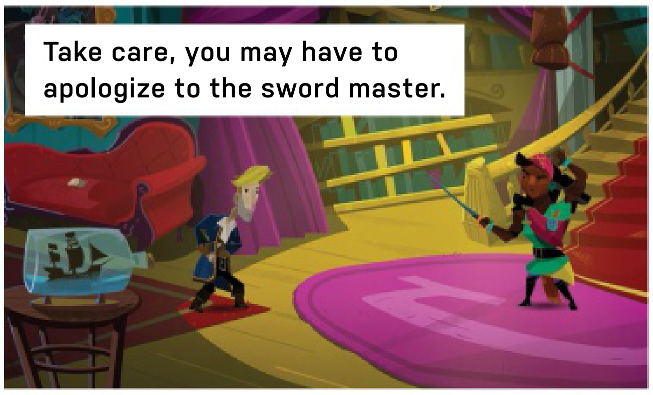
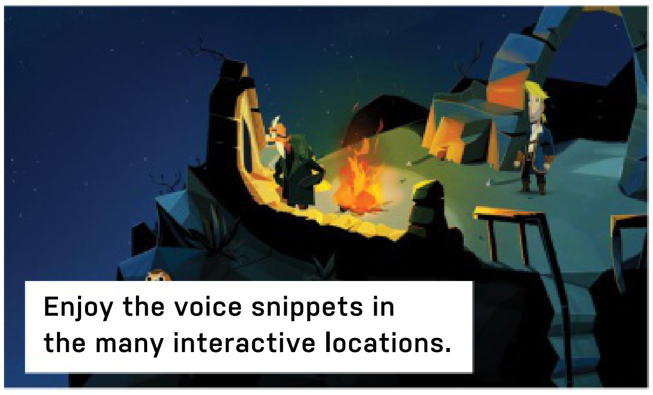
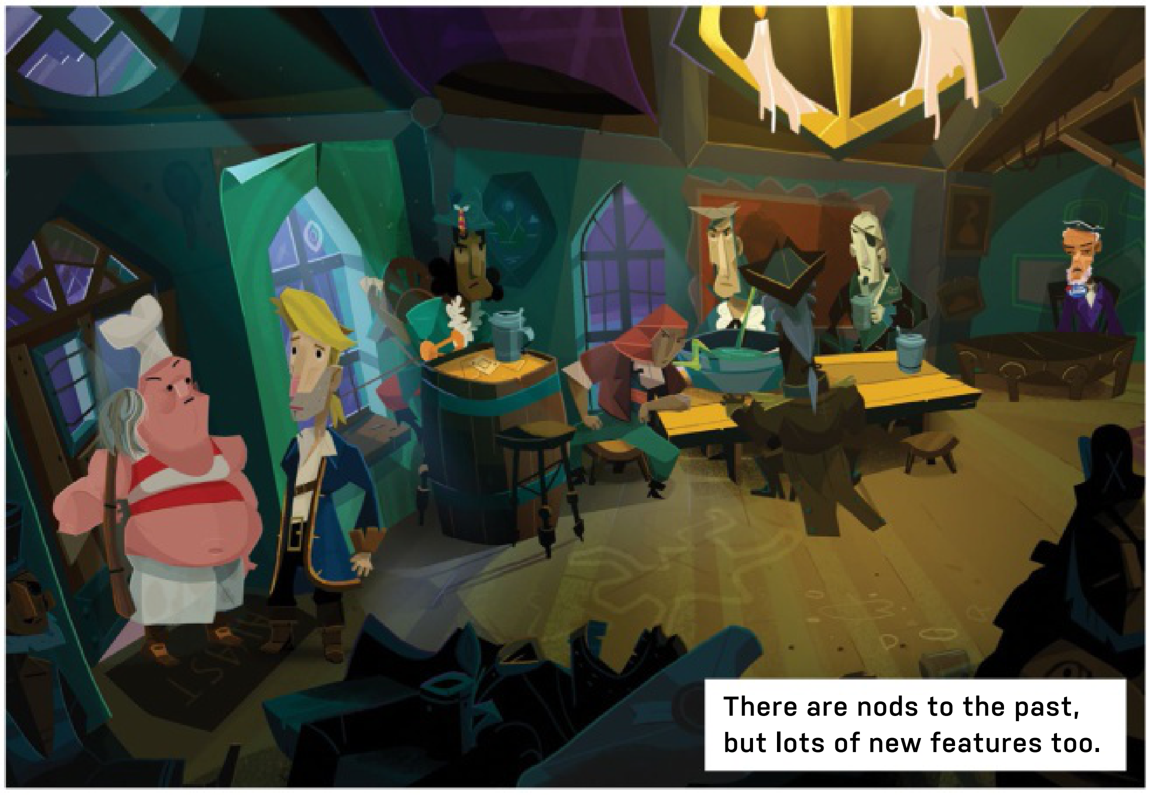

The bad guys aim to discover the secret of Monkey Island.


The art is colorful and detailed, looking and acting like a cartoon.


Take care, you may have to apologize to the sword master.


Enjoy the voice snippets in the many interactive locations.


There are nods to the past, but lots of new features too.

dialog if you missed what was said—simple additions that go a long way to making the process of playing completely transparent. There's no interface apart from a bag icon in the corner. The days of half the screen being filled with a list of words and an inventory are well over.

UTTERLY CHARMING

While Guybrush, who rather unfortunately sounds like Kermit the Frog, is recognizably human, the rest of the cast (particularly LeChuck and his ghost pirates) are so stylized as to be practically unrecognizable out of context. The art is utterly charming, from the disgusting rat wearing sunglasses as it relaxes in a particularly rotten puddle of whatever it is Scurvy Dogs are cooked in, to the frequent facial close-ups during the dialog that give you much insight into the speaker's personality.

The plot begins with the bad guys setting up their own expedition (aboard 'LeShip') to discover the secret of Monkey Island, with LeChuck and Guybrush accusing each other of stealing the idea. When your plan to get money to fund your own voyage falls through, you decide to join LeChuck but are turned away, setting in motion a chain of events that bounce from making a mop to apologizing to the sword master to a jailbreak.

As you progress, you'll discover trivia cards, which are kept in an album, each posing a question about *Monkey Island* lore. Answer correctly and you get to keep the card, get it wrong and you'll need to wait until it reappears and try again. It's an easy enough Google but also amusing to see which nuggets of information your mind has retained from 20 years ago.

The game is also absolutely tiny and will run on just about anything with more processing power than a potato. It's a great fit for the Steam Deck (it's verified), only takes up 4GB of your SSD, and for anyone still rocking an elderly PC, it's great to see a new game that will probably run on integrated graphics. Hook it up to a hot RTX card and a 4K monitor, and it scales up beautifully, the art style proving colorful and detailed enough to be interesting, even though a lot of it is flat color. The game looks like a cartoon and acts like one too.

Could *Return to Monkey Island* mark a renaissance for the point 'n' click game? We'd like to think it will, however, they never really went away. That the genre's most famous series has made a return after so many years away is going to pull in fresh eyes. And it goes some way to answering the question: why are pirate-based point 'n' click games so much fun? Because they arrrrrr! **–IAN EVENDEN**

VERDICT 9

Return to Monkey Island

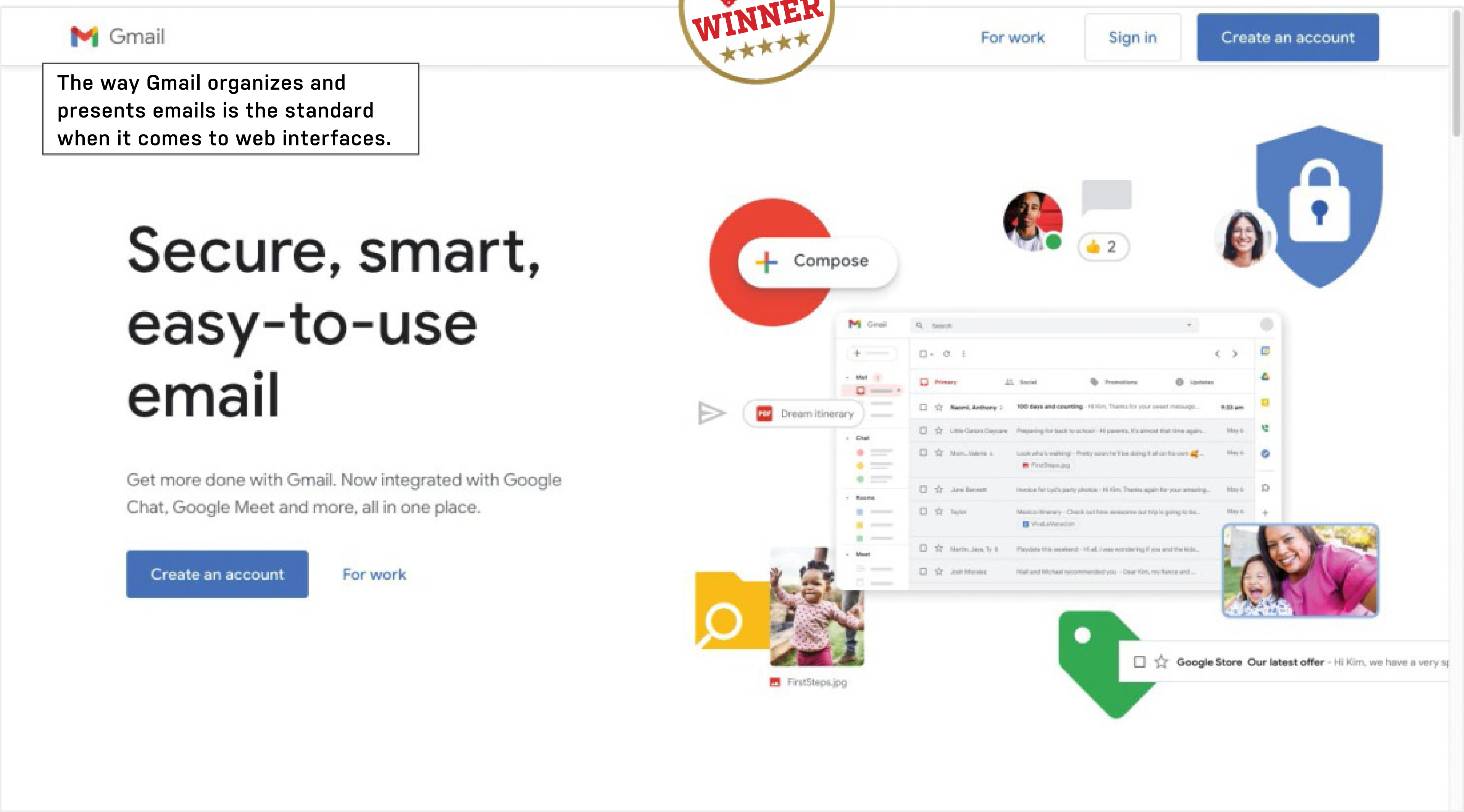
+ BOOTY Great script; engaging characters; runs on anything.

− SCABB We've had to wait a whole 13 YEARS for this!

RECOMMENDED SPECS CPU, AMD FX-4300/ Core i3-3240 or better. RAM, 8GB. GPU: Radeon HD 7750/GeForce GT 640 or better.

$25, returntomonkeyisland.com, not rated

HEAD TO HEAD WINNER ★★★★★



Secure, smart, easy-to-use email

Get more done with Gmail. Now integrated with Google Chat, Google Meet and more, all in one place.

The way Gmail organizes and presents emails is the standard when it comes to web interfaces.

© GOOGLE

Gmail vs. Outlook

What's the best platform for managing your email?

ABOUT 10 YEARS AGO, a previous employer of mine decided to move its email provider from Microsoft to Google. I was overjoyed. At the time, Outlook was tired, clunky, and ugly, while Gmail had a beautiful interface, a proper mobile app, and the ability to enable add-ons. This included one that could delay sending your email so you could go back and edit it or, for an ill-advised 11pm rant to the boss, delete it completely in the morning.

While Gmail is still the better-looking of the two, much has changed in the intervening years. Microsoft has improved its mobile apps, Microsoft 365 has become an integral part of the Windows 10 and Windows 11 experience, and new features such as the ability to see all your attachments in one place are genuinely useful. Gmail hasn't rested on its laurels either, rolling out new features such as the ever-popular Smart Compose predictive text input. It has also reduced users' storage, which combined with the back-pedaling of unlimited free Google Photos, is clearly an attempt to nudge users towards a paid subscription tier.

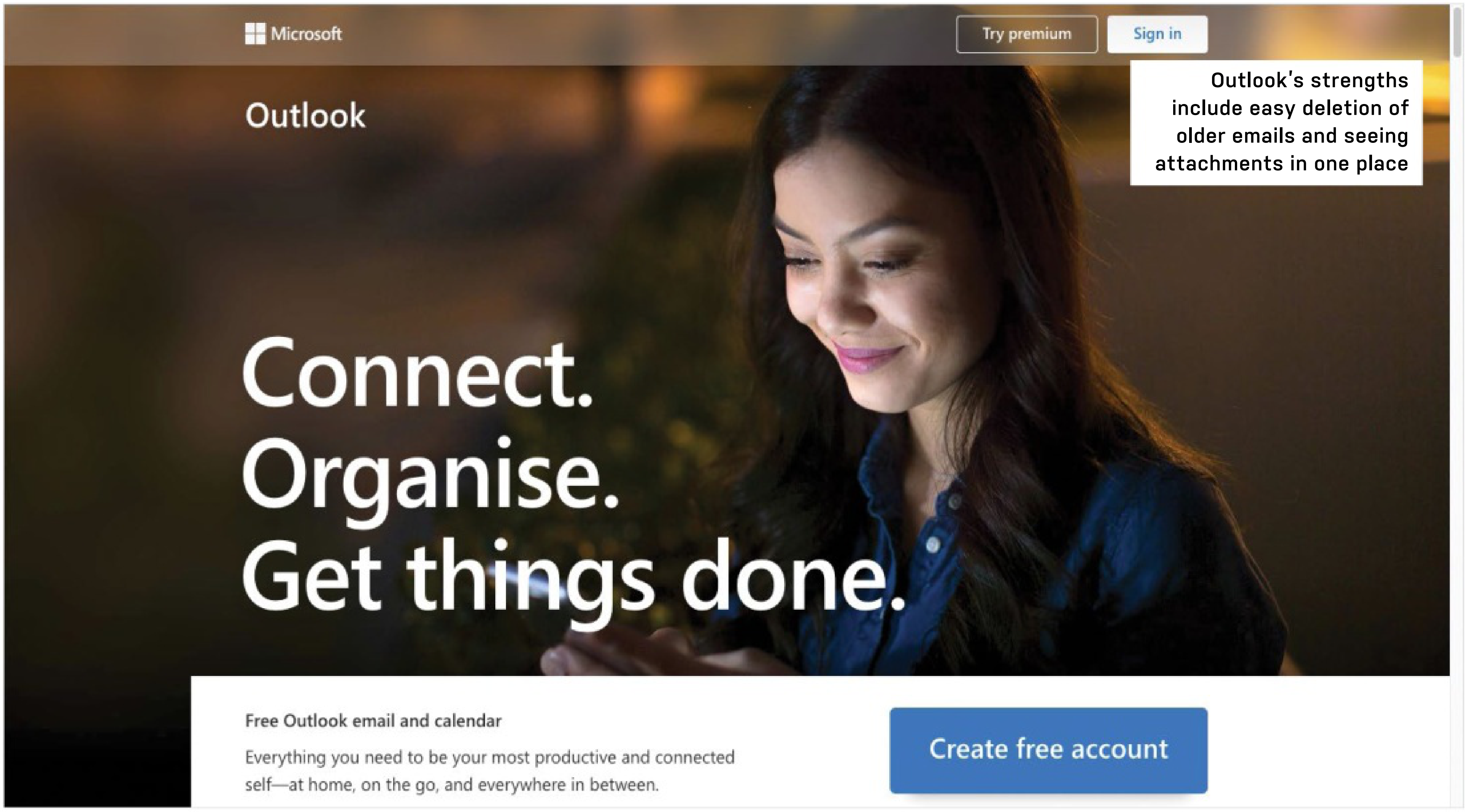
Let's start with Google because it feels like the default email provider for many. Gmail launched in 2004 with the promise of "never delete another email". It even had a ticker on the home page showing how its storage was gradually rising to cope with the new emails it was receiving.

Indeed, in 2006, Google told analysts that it was offering users "infinite storage", as it wanted people to store the "Golden Copy" of their data online and use local-machine versions as a cache. Back then, there was less demand upon email inboxes to cope with marketing blasts, scammers, and huge file attachments, and it fitted in with Google's stated business model, which was to harvest data to serve better advertisements. But along the way, whether due to rising storage costs, the industry's move towards recurring revenue, or a combination of both, Google started charging users for storage. Most users now have 15GB of free storage across all of Google's apps (the main storage hogs being Drive, Photos, and Gmail) before they are then forced to either delete content from their storage, or move onto the Basic 100GB storage plan, costing $1.99 per month.

Reflecting on Google's volte-face for this article, I feel genuinely aggrieved at being hoodwinked by Google's promise of forever free storage. I am now so hooked on its services that I essentially can't leave. As a result, I have to use the Unattach app (Unattach.app, $9.99 per year) to annually strip out the larger attachments and back them up to my NAS. Google One, the company's storage hub, will sort and present the largest emails in your inbox, but you have to delete the entire email—you can't strip out the files and keep the original message.

If storage is your main priority, another alternative is Yahoo Mail, which offers a huge 1TB of free storage per account. Yahoo has an excellent email import feature that would make migrating easier, but I can never quite bring myself to complete the switch as all my other online accounts are linked to my Gmail address.

Meanwhile, Outlook comes with the same 15GB of free storage for users. However, it is better at allowing you to save space, as you can delete items from your inbox that are greater than three, six, or 12 months old with just a couple of clicks. You can't strip out attachments, but Outlook has a "Files" tab that allows you to see all the photos and documents from your emails in thumbnail view. If you want to upgrade your storage in Outlook there's only one way to do it, and that's to



Connect.
Organise.
Get things done.

Free Outlook email and calendar

Everything you need to be your most productive and connected self—at home, on the go, and everywhere in between.

Outlook's strengths include easy deletion of older emails and seeing attachments in one place

pay for Microsoft 365, which is $6.99 per month and bags you 50GB of space. That's terrible compared with Google's 100GB for $1.99 per month, but it's an apples-to-oranges comparison, as Microsoft 365 also gets you 1TB of OneDrive storage, the Office suite of apps, an ad-free Outlook experience, premium support, and quite a bit more. True value is offered by Microsoft 365 Family, which is $9.99 per month and covers up to six people, effectively $1.67 per month per user. Again, both offerings pale in comparison to Yahoo and its free 1TB storage.

FAST AND FUSS-FREE

If you're in the Microsoft ecosystem with Windows or Office, then 365 is especially worth paying for, particularly OneDrive syncing in Windows. Likewise, the Mail app in Windows is set up by default with your Outlook address and is a fast and fuss-free way of managing all your email accounts. The Outlook Windows app is also available if you need more features, such as the ability to read your emails aloud. The Outlook mobile app (Android and iOS) is well-designed, making it easy to manage all your accounts from one place. We like the ability to add your storage accounts in Outlook, including OneDrive, Box, Dropbox, and even Google Drive, and access them to send attachments from within the app or website.

On mobile devices though, particularly Android, Gmail's app has the upper hand. You can email and video chat from within the same app, and if your company runs on Google, you'll also see Chat and Spaces along the bottom navigation. There's no Gmail app for Windows, but you can install Google Drive to keep your files synced across devices. The Gmail web interface is also powerful without feeling overwhelming, with a slick design housing loads of useful features.

In this always-connected world, the web interface is where most people interact with their email, and this is where Google pulls away from Microsoft. Google's interface is nicer to look at, easier to use, and doesn't feature ads. Important features such as "Send Later" and "Smart Compose" are enabled by default, allowing you to decide to send your email the following day or save time composing standard responses respectively. These features are available on Outlook, but you have to dig in the settings to find "Undo Send"—a delay time that you can apply to every message before it leaves your Outbox. Meanwhile, "Suggested Replies" only applies to responses, not original messages.

While the introduction of the above features has mitigated the need for add-ons in Gmail, they're still there if you want to play around. The best ones allow you to integrate other applications such as Zoom, Todoist, and Dropbox. We particularly like Inbox When Ready, which hides the inbox when you log in, so you can focus on sending that important message without being distracted by unread emails. Outlook has lots of useful add-ins to do things like strip attachments from emails while keeping the original message, but they're for the app, not the web interface.

Over the last few years, Gmail has gotten worse thanks to its reduced free storage policy, while Outlook has improved its mobile apps and Windows integration. However, Gmail remains the top dog, thanks to its beautiful design, wealth of features, and integration into the wider Google suite. While that 15GB storage might be a constraint over time, it's still the best way for most people to manage their emails. **–GUY COCKER**

VERDICT 9 **Gmail**

⊞ **ARCHIVE** Beautiful interface; no ads; Send Later and Smart Compose features; wealth of add-ons.

⊟ **DELETE** 15GB free storage limit; no Windows app.

$free, www.gmail.com

VERDICT 8 **Outlook**

⊞ **SEND** Great apps for PC and mobile; thumbnail view for attachments; lots of Outlook app add-ins .

⊟ **DELAY** Clunky interface; no add-ins for web app; more limited features.

$free, www.outlook.com

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LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> RGB Harmony
> BIOS Blues
> Time To Upgrade?

Light of My Life

I'm currently doing a build. Yes, I'm going for components with power I don't need, but who cares? I'm a retired IT guy, so it's all fun! So, I appreciate all your info on power, cores, and overclocking. I love it!

That said, what I need is an article on RGB lighting. I'm buying an Asus motherboard that uses the Aura lighting standard, then I'm looking at Corsair fans, which use the iCUE standard. How about an article for builders that talks about the best way to put on a 'light show'? **– D.Champagne**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: First of all, congratulations on your build, but you've left us all hanging—how did it go? Please send in pictures to show us what it looks like. Second, what a fantastic idea for a feature. I have to admit, the amount of great feature ideas I receive from *Maximum PC* readers makes my job as editor much easier!

As I sit here looking over my own desktop setup, I have RGB-enabled components from Gigabyte, HyperX, Adata, DEEPCOOL, upHERE, Logitech, and Alienware—seven different companies each with different lighting standards. It can be easier to use one company's products when trying to sync—Corsair springs to mind as it has RAM, coolers, and peripherals, but this is PC building we're talking about! It feels antithetical to the platform to not be able to mix and match components!

My recommendation is to start with whatever app controls your motherboard, so in my case, Gigabyte RGB Fusion 2.0, and see what that can control. Chances are it will sync up the items inside your case for a more uniform look.

Which leads me nicely onto our next letter...

SignalRGB Satisfaction

I was looking back at the June issue and saw your lament about RGB brands. I've got quite the hodgepodge myself, with a Corsair case, RAM and keyboard, a Gigabyte motherboard, Phanteks lighting, generic LED strips... the list goes on.

Controlling it was a nightmare, but luckily, I came across SignalRGB. The program isn't perfect—it claims that it controls fans, but it doesn't work on my system. However, I deleted iCue and RGB Fusion and found that SignalRGB works a treat to control and sync all my RGB lighting.

There are plenty of amazing profiles, with game and music sync options as well. There are also free and subscription versions. If you like geeking out on RGB, it's well worth checking out! **– R.Matlow**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: As Ms. Matlow says, if you want more granular control, you're going to need a specialist app. SignalRGB is a great app that works across most of the major brands. For what Mr. Champagne is looking for, he can probably get away with the free basic version of the app, but quite a few of the cool features mentioned above require the Pro version, which is $5 per month (cheaper annual subscriptions are available). While that's quite a lot for something aesthetic, if you've already dropped money on RGB-enabled components, chances are you want to actually use them as intended! No one said the RGB life came cheaply!

There's clearly something in the air when it comes to RGB lighting this month, so I'll take a look at this for an upcoming feature.

BIOS Boosts

Thanks for another great issue of *Maximum PC*. The October issue cover states 'Simple two-minute BIOS boosts', but the only mention I could see was on page 25 about updating the BIOS! Did I miss something? **– D.Hamilton**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: Glad you enjoyed the issue and sorry you missed the BIOS tips which were a few pages further on page 30.

As Sam said, when setting up your PC, you want to take the time to download the latest version of the BIOS and get it installed to make sure your computer is running at peak performance with

↘ submit your questions to: editor@maximumpc.com the best security. This is something that a lot of laptops remind you to do automatically, but it's worth checking every few months on your desktop PC. Remember to back up your BIOS settings too, if possible!

As Sam said in the issue, go into the overclocking section of your BIOS, if it has one, and make sure your RAM is running with XMP settings, which in this case was called 'XMP 2.0 Profile'. It's something that many of us, myself included, often forget to do, but is a quick and easy way of adding more performance to your system. More advanced builders may want to tweak their RAM timings further, something that can also be done from this screen.

Our October issue has lots more 'one-click' overclocking and performance hacks that are worth checking out, including the Intel Extreme Tuning Utility and MSI Afterburner. It's easier than ever to eke out a few extra frames in your games these days, so why not have a read and give it a go?

Apple Appreciation

I just want to say, I love the magazine. I first subscribed during my teenage years in the early 2000s when it used to come with a CD (or DVD?) every month filled with utilities and sometimes a game demo. Exciting stuff for a kid on a 768kbps DSL connection!

I was reading the September issue and saw a question posed in the letter section asking how many Apple users are out there [*raises hand*]. I started a managed service provider business 15 years ago and have found that being 'fluent' in both Mac and Windows is a necessity.

I have a hand-built PC desktop I use in my home office most of the time. However, when it comes to being out in the field working with clients, I go all Apple—iPhone, AirPods, and MacBook Air M2 at the ready. I would echo G.Jones's statement about Apple devices being tools in the sense they work when you need them to work.

I love my PC—the flexibility Windows offers, the wide array of software available, and how immersed in the Office 365 suite of business services it can get. I even enjoy a couple of hours of *Star Wars Battlefront* or *Red Dead Redemption 2* on my RTX 3080 once in a while, even though most of the time it's under-used with spreadsheets and web browsers. But when it comes to being in the field and on the clock, I put Apple in my toolkit.

– M.Cummins

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: Your letter demonstrates that, far from being a Mac vs. PC debate where there can only be one winner, the two platforms actually complement each other well. They serve different purposes and different markets, even when people such as Mr. Cummins here find themselves at the center of a Venn diagram across the two.

I am forced to carry two laptops for work when traveling—my company's Macbook Pro for working on the magazine, and my PC laptop for gaming. It's frustrating, but I can see why our publisher uses the Mac. Beyond it running the publishing software we need (which, I should mention, is also available on PC), it's as dependable a computer as I've ever used. It works well when I need it to, the battery lasts for days, and it's light enough to not weigh me down if I'm spending all day traipsing around a convention.

I also want to mention the Apple difference when it comes to resolving a problem. As I'm sure all of you have experienced, there are times when PCs can go wrong, and even the most experienced builders can be left tearing their hair out trying to figure out a solution. Sure, there are a wealth of manuals, forums, and YouTube tutorials online, but sometimes you have to admit defeat and call in an expert, which can be tricky if you're on a self-built machine.

The times when I've had a problem with a Mac, however, I've been able to go into a local Apple Store and have a new logic board or screen installed within a day or at most a week. Sometimes the repair and the replacement parts have even been free.

I suspect this is one of the reasons the mass market feels so comfortable with a Mac—they are still slightly scared of computers, and Apple's legendary service quality makes them feel a bit more reassured.

Shiny New Toys

I'm sure a lot of your readers are wondering this at the moment, but with all the new hardware announcements recently, is it time for me to upgrade my desktop PC?

I'm running a system with an Intel Core i9-11600K, RTX 3080, PCIe 3.0 SSD, and DDR4 RAM, and I'm seeing all of the new products set to land from Intel and Nvidia (and AMD!) before Christmas and wondering whether now's the time to buy, or whether I try and get another year out of my current system.

Also, while we're at it, I currently have a 4K Dell S3222DGM 32-inch 1440p monitor, but I'm eyeing up an ultrawide so that I can be more productive at work. Any suggestions that are also good for gaming in the evening? **– E.Bright**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: As you say, it's an interesting time for PC owners at the moment—we've not been able to buy a lot of new gear for reasonable prices over the last two years, and now, all of a sudden, there are lots of shiny new things with blazing performance available to purchase!

In this issue, we have reviews of the new flagship CPU from AMD and GPU from Nvidia, both of which are excellent. But when we review new products in *Maximum PC*, we do it objectively, comparing it with other products on the market. It's harder to give advice on whether to upgrade from, say, an 11th gen. Intel chip to an AMD Zen 4 processor. But look out for lots of builds in the coming issues that will try to address which are the best products for designers, gamers, photographers, and so on.

In your case, I'd hold off for now, as hard as that may be. Intel's new processors will be going through our labs next month, while rumors are AMD's X3D gaming-focused chips should be here as soon as next year. We should also have Nvidia's two 4080 cards in shortly, as well as whatever AMD comes up with in the graphics space. Buyers should wait to see how that all shakes out before committing to Intel Raptor Lake or AMD Zen 4, or indeed Nvidia Ada Lovelace, or AMD RDNA 3.

As for your monitor, I too have fallen in love with ultrawides. I reviewed the HP X34 in the September issue and was blown away by how good it was for $400. However, it led me this month to purchase Alienware's AW3423DW OLED. It's $1,300, which is way more than HP's monitor, but it's by far and away the best screen I've ever gamed on. ⏻

THE BUILDS

THIS MONTH'S STREET PRICES...

BUDGET

AT THE TIME OF WRITING, a whole new range of chips and GPUs are available. Exciting times, then, for our new blueprint machines? Well, yes and no. For the mid-range and turbo machines, yes, but unfortunately we don't get to add these new toys into our budget machines just yet. For now, our budget CPUs and GPUs don't alter.

For team Intel, that means that the trusty Core i5-12600K is once again at the wheel, although it does partner up with a new GPU. Yes, we know we just said nothing had changed, but hold on, it's nothing to get too excited about. Fluctuations in pricing mean that we swap out our previous MSI graphics card for a similarly specced Zotac one. This GPU is an RTX 3060 OC like the MSI and has 12GB of GDDR6 to play with. It's nothing revolutionary but is still a great buy for under $400.

Aside from that, the PSU is swapped out for an Asus ROG Strix unit that has the same wattage but a higher efficiency rating. Now we get to see an 80+ Gold PSU instead of an 80+ Bronze one—and for the same price too.

Over on team AMD's budget rig, there aren't too many drastic changes this time either. The driver behind the wheel here also remains the same but, unlike the Intel machine, we keep the existing GPU. What we do get is a sale bringing our MSI MECH 2X OC Radeon 6650XT card down by $22, not a bad saving at all.

Where we have swapped out parts is in our storage and power supply. Corsair's trusty MP600 PCIe 4.0 SSD comes in to take the role as our main storage solution while Seagate's SkyHawk Surveillance remains in place as our backup HDD with a large 4TB capacity. Another similarity to the Intel machine is that we've also replaced an 80+ Bronze-rated PSU for an 80+ Gold-rated unit with a Cooler Master MWE Gold 550W unit. Prices on all other components have remained fairly stable with no major fluctuations, which is a good thing for those on a budget.

AMD INGREDIENTS

PART		PRICE
Case	Corsair 4000D Airflow	$95
PSU	550W Cooler Master MWE Gold 80+ Gold **NEW**	$60
Mobo	MSI B550M PRO-VDH WiFi AM4	$119
CPU	AMD Ryzen 5 5600X	$195
GPU	MSI Radeon RX 6650 XT MECH 2X OC 8GB	$308
RAM	16GB (2 x 8GB) PNY XLR8 Gaming EPIC-X RGB @ 3600MHz	$65
SSD	500GB Corsair MP600 PCIe 4.0 M.2 **NEW**	$65
HDD	4TB Seagate SkyHawk Surveillance 7200	$88
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32
Approximate Price:		**$1,027**

INTEL INGREDIENTS

PART		PRICE
Case	Corsair 4000D Airflow	$95
PSU	550W Asus ROG Strix 80+ Gold **NEW**	$70
Mobo	ASRock B660 Pro RS LGA 1700	$109
CPU	Intel Core i5-12600	$230
GPU	Zotac GeForce RTX 3060 GAMING TWIN EDGE OC 12GB **NEW**	$380
RAM	16GB (2 x 8GB) PNY XLR8 Gaming EPIC-X RGB @ 3600MHz	$65
SSD	500GB MSI Spatium M450 PCIe 4.0 M.2 SSD	$60
HDD	4TB Seagate SkyHawk Surveillance 7200	$88
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32
Approximate Price:		**$1,129**

MID-RANGE

FOR THE BUDGET RANGE we didn't see anything too exciting, but here, we can start to introduce some of the latest components to futureproof our mid-range machines. That's right, AMD's Raphael CPUs and Intel's Raptor Lake chips have joined the party and we welcome them both with open arms. It means we've stretched our wallets slightly to bring these fresh processors in, but for their benefits, it's worth it. For our AMD build, welcome the 6-core Ryzen 5 7600X. At $299, it has 12 threads, a maximum boost frequency of 5.3GHz, and features an AM5 socket.

By changing this CPU, we have to upgrade to an AM5 motherboard and, as our mid-range budget isn't quite as forgiving as our turbo builds, we've opted for one of the cheapest compatible ones on the market, the Asus PRIME B650M-A AX Micro ATX. There's nothing special going on here, but it's still a respectable board to house our new chip. This has also resulted in an upgrade to DDR5 RAM with Corsair's 32GB Vengeance kit. Although we've spent more on upgrading this machine, a sale of around $90 on our ASRock Radeon RX 6800 XT helped us out.

For the Intel machine, we didn't need to change the motherboard as the new 13th gen Raptor Lake chips run on the same LGA-1700 socket as the previous Alder Lake processors. However, we changed it to the MSI PRO Z690-A for its DDR5 support and brought in the same Corsair RAM we used for the AMD build. As for the CPU, this is the new Intel Core i5-13600K. Containing 14 hybrid cores (six performance and eight efficient), this latest i5 chip has four more cores than last year's 12600K and a four percent turbo boost frequency, to 5.4 GHz.

One final change on the midrange Intel build is the GPU. A sale on newegg.com sees Gigabyte's GAMING OC 3070 Ti card slip under the $600 mark. This is a welcome addition to the build but, that aside, the rest of the components stay the same as before.

AMD INGREDIENTS

PART			PRICE
Case	NZXT H7 Flow		$130
PSU	750W NZXT C750 80+ Gold		$90
Mobo	Asus PRIME B650M-A AX Micro ATX AM5	**NEW**	$199
CPU	AMD Ryzen 5 7600X	**NEW**	$299
Cooler	Cooler Master MASTERLIQUID ML240L RGB V2		$90
GPU	ASRock Radeon RX 6800 XT Phantom Gaming D OC 16GB		$550
RAM	32GB (2 x 16GB) Corsair Vengeance DDR5 CL40 @ 5200MHz	**NEW**	$150
SSD	1TB Crucial P5 Plus NVME M.2 PCIe 4.0		$117
HDD	4TB Seagate SkyHawk Surveillance 7200		$88
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)		$32

Approximate Price: $1,745

INTEL INGREDIENTS

PART			PRICE
Case	NZXT H7 Flow		$130
PSU	750W NZXT C750 80+ Gold		$90
Mobo	MSI PRO Z690-A ATX LGA 1700	**NEW**	$160
CPU	Intel Core i5-13600K	**NEW**	$330
Cooler	Cooler Master MASTERLIQUID ML240L RGB V2		$90
GPU	Gigabyte GeForce RTX 3070 Ti GAMING OC 8GB	**NEW**	$590
RAM	32GB (2 x 16GB) Corsair Vengeance DDR5 CL40 @ 5200MHz	**NEW**	$150
SSD	1TB ADATA XPG GAMMIX S70 M.2 PCIe 4.0		$109
HDD	4TB Seagate SkyHawk Surveillance 7200		$88
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)		$32

Approximate Price: $1,769

UNFORTUNATELY, THE LATEST GPUs arrived just too late to sneak into our builds. We prioritized our review of the RTX 4090 this issue, but expect that card to appear in our builds and blueprints next issue. Kicking things off on team Intel, we replaced our i9-12900K with the Intel Core i9-13900K. This monster of a processor again features a hybrid architecture with a total of 24 cores (eight performance and 16 efficient), which is eight more than the previous 12900K. There was a price jump of $190, but savings elsewhere went in our favor.

We included the same RAM sticks from the mid-range machines but opted for the 64GB variant, saving $110. We didn't need to swap our mobo out to accommodate the new chip, but a sale has brought it down from $270 to $235, justifying our decision to stick with the Asus TUF GAMING Z690-PLUS WIFI.

Though we included the top new CPU from Intel in that build, we won't be using the top AMD Ryzen 9 7950X. Instead, we have the next best thing, the AMD Ryzen 9 7900X. It's still an awesome piece of hardware, is $150 cheaper than the Ryzen 9 7950X, and outperforms the previous chip in this build, the Ryzen 9 5950X while costing around the same. However, this means a new AM5 motherboard has to be brought into the equation. We've gone with a great performing one too, featuring the fastest chipset available, the AMD X670 Extreme. This gives us great futureproofing, with the most compatibility and overclocking potential. The CPU alteration also means we need a new cooler, the Cooler Master MasterLiquid ML360R RGB AIO, which should keep our system running smoothly for the same price. We kept the same ASRock OC Formula Radeon RX 6950 XT GPU in the build as it's still an outstanding graphics card.

The DDR5 Corsair Vengeance is a great pick-up for the price to go in the AMD build. Finally, there was one other change to both machines, and that was the PSU. Both now see the 1000W EVGA SuperNOVA 1000 GT 80+ Gold for some healthy futureproofing.

AMD INGREDIENTS

PART			PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass		$190
PSU	1000W EVGA SuperNOVA 1000 GT 80+ Gold	NEW	$115
Mobo	ASRock X670E PG Lightning ATX AM5	NEW	$244
CPU	AMD Ryzen 9 7900X	NEW	$550
Cooler	Cooler Master MasterLiquid ML360R RGB 66.7 CFM 360mm	NEW	$155
GPU	ASRock OC Formula Radeon RX 6950 XT 16GB		$870
RAM	64GB (2 x 32GB) Corsair Vengeance DDR5 CL40 @5200MHz	NEW	$280
SSD	1TB WD Black SN850X M.2 PCIe 4.0		$135
HDD	6TB WD Blue 5400 HDD		$99
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)		$32
Approximate Price:			**$2,670**

INTEL INGREDIENTS

PART			PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass		$190
PSU	1000W EVGA SuperNOVA 1000 GT 80+ Gold	NEW	$155
Mobo	Asus TUF GAMING Z690-PLUS WIFI DDR5 LGA 1700		$235
CPU	Intel Core i9-13900K	NEW	$660
Cooler	NZXT Kraken X73 73.11 CFM 360mm		$160
GPU	Gigabyte GeForce RTX 3090 Ti Gaming GAMING OC 24GB		$1,460
RAM	64GB (2 x 32GB) Corsair Vengeance DDR5 CL40 @5200MHz	NEW	$280
SSD	1TB WD Black SN850X M.2 PCIe 4.0		$135
HDD	6TB WD Blue 5400 HDD		$90
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)		$32
Approximate Price:			**$3,397**

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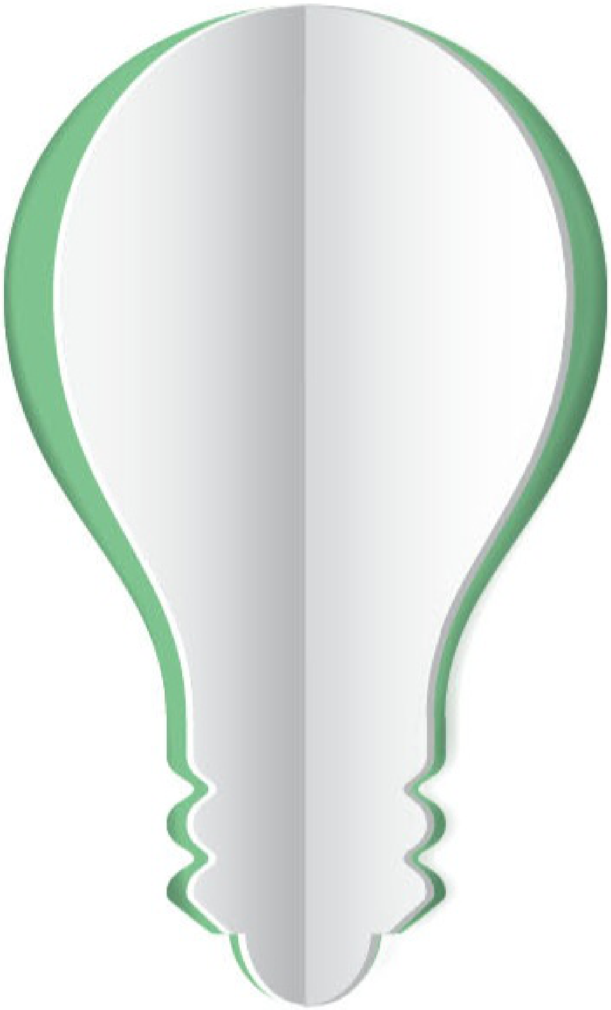

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Source: American Forest & Paper Association, 2022

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